Socioeconomic and Ecological Consequences of Biofuel Development in India

M.S. Umesh Babu and Sunil Nautiyal

Norsk Utenrikspolitisk Institutt
Norwegian Institute of International Affairs

NUPI Working Paper 807
Department of International Economics

Publisher: Norwegian Institute of International Affairs

Visiting address: C.J. Hambros plass 2d
Address: P.O. Box 8159 Dep.
NO-0033 Oslo, Norway
Internet: www.nupi.no
E-mail: info@nupi.no
Fax: [+ 47] 22 99 40 50
Tel: [+ 47] 22 99 40 00

Socioeconomic and Ecological Consequences of Biofuel Development in India

M.S. Umesh Babu and Sunil Nautiyal

Centre for Ecological Economics and Natural Resources (CEENR)
Institute for Social and Economic Change (ISEC)
Dr. V.K.R.V. Rao Road, Nagarabhavi, Bangalore - 560 072, India

Abstract

This paper provides an overview on biofuel production and its pros and cons in India and elsewhere. The paper also discusses the major issue of whether biofuels are an alternative to fossil fuels or are a competitive for food production. It examines benefits for the rural poor by providing additional income, employment, land value, etc., and the circumstances of the biofuels market and its inputs for GDP growth in India. However, of late, biofuels and their production have failed to address challenges like supply of water and food security,for the growing population in India as well as many other developing countries in the world. This paper highlighted these issues in detail particularly disadvantages of biofuel production.

Keywords: Biofuels, Food insecurity, Water insecurity, Environmental benefits, Socioeconomic changes

This paper is a publication from the project "India and globalisation: Regional disparities, industrial development and inclusive growth (INGRID)". Financial support from The Research Council of Norway (Project No. 205128/S50) is gratefully acknowledged.

Introduction

Biofuels are solid, liquid, or gaseous fuels which are consisting and derived from biomass, *recently living organisms,* or their metabolic byproducts such as manure from livestock. Biodiesel is a liquid fuel, technically known as a mono alkyl ester, made up of fats or oils, and alcohols. Fossil fuels are derived from *long dead* biological materials (Nan Shi, 2009). Biofuels are often considered as a transitional renewable energy source to hydrogen fuel cell, nuclear, solar, or wind energy. Initially, biomass was considered for human beings and then it was diverted to fuel production (first generation process). During the second generation processes make use of the vast majority of the feedstock to avoid the kind of waste inherent in the production of first generation biofuels. Then the projection of third generation by 2022, biofuels will be the largest global fuel source, accounting for 37 per cent (40 billion gallons) of total biofuels production (on a volumetric basis)[1]. Today, fuel in the form of ethanol can be extracted from an environment friendly natural products such as sugarcane, maize (corn), and sorghum. It is a non toxic, biodegradable, and will benefit the environment by reducing the GHGs and local pollution through lower emissions of carbon dioxide (CO_2) (Muller, 2010). Since 1900 diesel engine was adapted in refiniary process to produce by-product and getting expanding widely. Dr. Rudolph Diesel was the innovater of this engine then it is named as diesel engine. March 13 of every year as celeberated as Biodiesel Action Day for a memory of Dr. Diesel.

Biofuel production is not considered truly as carbon-neutral because the stages of production needs non renewable energy while transporting and processing. The drawbacks of biofuel production are many and found in many research also, among them major are deforestation by clearing huge green area, soil erosion by extensive farming practices, over utilization of groundwater, food insecurity etc. However, it reduce the socioeconomic burdens and improves the livelihood of people through additional income and also increase the value of the land. Besides, biofuel adapation with conventional fuels control the global warming and reduce the emissions of GHGs.

---

1 Source: (http://www.researchandmarkets.com/reports/1202816/biofuels_2010_spotting_the_next_wave accessed:02.01.2012)

Figure 1: Global Atmospheric CO2 Concentrations

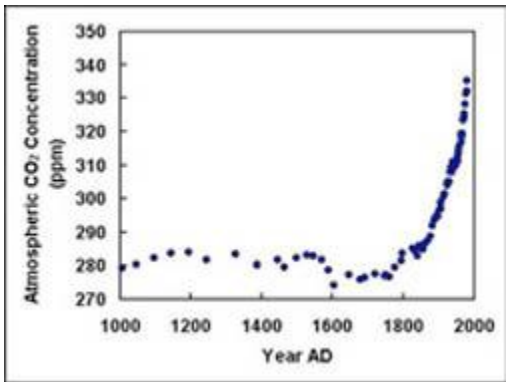
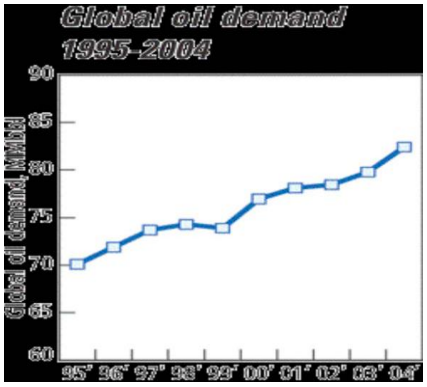


Figure 2: Global Oil Demand 1995-2004



Source: http://www.biofuels.coop/pdfs/1_intro.pdf

Figure 1 shows the carbon dioxde level increase in the global atmosphere across the year. It highlights the level of conventional energies burned across the world. The application of biofuel as substitute for fossil fuels will minimize the emissions level in the atmosphere and provides pollution free environment for the living organisms. Figure 2 explain the oil demand over the years. The production of biofuel will substantiate the the further demand in the global oil market. Moreover, biodiesel (B100) yields 3.2 units of fuel product and energy for every 1 unit of fossil energy consumed in its life cycle. The production of B20 yields 0.98 units of fuel product energy for every unit of fossil energy consumed. Substituting 100 per cent biodiesel (B100) for petroleum diesel in buses reduces the life cycle consumption of petroleum by 95 per cent. This benefit is proportionate with the blend level of biodiesel used. When 20 per cent of blend biodiesel and petroleum diesel (B20) is used as a substitute for petroleum diesel in urban buses, the life cycle consumption of petroleum drops 19 per cent (www.ott.doe.gov/biofuels/docs/lifecycle.html). For example, in Europe, rapeseed oil is used as primary feedstock to make biodiesel (in 2008, the EU used about 60 per cent of its rapeseed harvest to replace 3 per cent of its diesel consumption). In USA, soybean oil is the primary feedstock used to make biodiesel because it is the largest soy producer in the world (in 2008, the US allocated approximately 33 per cent of its entire corn crop to replace about 5 per cent of its gasoline needs), further demand can be found in table 1.

Table 1: Comparing the Biofuel Agendas

India	EU	Brazil	Thailand	Canada
Substitution of 10 % oil requirement by 2032`	By 2020, 10 % transport oil used will be green	Biodiesel will make for 5% in 2013	Biofuel to meet its 2 % of its total energy needs by 2010	By 2010, 45 % automotive fuel sold will 10 % doping

Source: Sahai, Online.

The Indian biofuels market has been consistently witnessing growth and development for the past few years.[2] On the back of these developments, the Indian ethanol consumption is projected to grow at a CAGR of around 4 per cent during 2009–18[3]. Ethanol consumption is expected to grow more rapidly than domestic production, thus creating an ethanol import scenario during the forecast period. In 2008, ethanol production displaced 3.7 per cent of global gasoline consumption, while biodiesel accounted for 1.5 per cent of the global diesel market (on equivalent Btu levels).[4]

Biofuels Development in India

India is the fifth largest energy consumer in the world (Adholeya, 2007). Producing biodiesel from tree-borne oilseeds it seen as a win-win opportunity to solve two of India's most pressing problems. First, India needs to stimulate rural development. Agricultural growth lags far behind comparing to manufacturing and services, reflecting a lack of investment and low productivity in the sector. Three-quarters of India's poor people live in rural areas and their prospects and livelihood depends only on agriculture activitites if growth in agriculture condence difficult to overcome through a poverty line. Second, India's increase energy consumption, from 1990–91 to 2006–07, the country's oil imports increased dramatically from 21 to 111 million tons (Altenberg et al., 2008). As economic growth continues to be strong and international energy prices quickly go up, the country's foreign exchange expenditure for oil imports are skyrocketing. Biodiesel might stimulate agricultural development and create employment and income for many of the rural poor (Altenberg et al., 2008).

Andhra Pradesh has been one of the front runners in promoting biofuels in India (Prabhakar,et al, 2010). The state government is attempt-

2 Source: http://www.researchandmarkets.com/reports/1929665/biofuel_industry_in_india acessed:02.01.2012

3 http://www.articlecity.com/articles/business_and_finance/article_14574.shtml acessed:04.01.2012

4 http://www.rncos.com/Press_Releases/Ethanol-Consumption-to-Show-Strong-Growth-in-India.htm accessed:05.01.2012

ing to meet energy needs by integrating biofuels feedstock production of plants like Jatropha and Pongamia. Statistics indicate that nearly 15,000 ha are active as biodiesel plantations (both Jatropha and Pongamia) out of the 16,000 hectares in the 13 rain shadow districts (rain deficient areas of the state) and these areas are identified as suitable for growing Jatropha and Pongemia (Prabhakar,et al, 2010).

Biofuel Scenario in India

The past President of India, Dr. Abdul Kalam was the strong motivator of biofuel production in India. Dr. Kalam suggested that over and above 50 percent of the wasteland area can be brought up under the biofuel production. Soon after many state government including private companies were started approaching the development of biofuel. Moreover Indian railways begin in mixing biofuel with other conventional fuel. Likewise, Reliance industries made agreement with Andhra Pradhesh government to develop 200 acres of Jatropha plantations. Similarly Mysore based private company started developing Jatropha plants in semi arid regions of Karnataka. Apart from Chattisgarh Government in the year 2006 planned massive plantations of (about 160 million saplings) Jatropha throughout the state with support from central government. At the same time Tamilnadu government planned to distribute Jatropha plants to farmers to uplift their household income due to irregular rains. In addition other lead private companies were came forward for the plantations of Jatropha. Thus, Tamilnadu government abolished the tax on Jatropha purchase. Similarly Government and private companies of Rajasthan, Maharastra and Gujarat has focussed on the expansion of biofuel plantations[5].

Biofuels Policy in India

The Government of India is currently discussing a National Biofuels Policy, for blending of fossil diesel with biodiesel compulsory. Moreover, well funded government programmes for rural development are already used to subsidize the establishment of biodiesel plantations on a large scale throughout India. While the federal policy is still under discussion, several state governments took the lead and established their own biofuel policies, each setting its own priorities and employing particular policy mixes. (Altenberg, et al, 2008).

India has begun biofuel programmes after the National Biofuel Policy and still in the process of preparing a policy aimed activities for the development of biofuel sector. The proposed policy will cover research and development, capacity building, setting up a minimum support price for Jatropha and other non-edible oilseeds and also

5 http://en.wikipedia.org/wiki/Biofuel_in_India: accessed 15.09.2012

norms for purchases and registration to enable biofuel use. The plan is to start with a blending proportion of 5 per cent (5 per cent biofuel with 95 per cent conventional fuel) by 2012, 10 per cent by 2017 and over after 2017.

In India, biofuels are a ray of hope in providing energy security. Biofuels are environment friendly fuels and their utilization would address global concerns about containment of carbon emissions. The transportation sector has been identified as a major polluting sector. Therefore biofuels can increasingly satisfy the energy needs in as environment friendly and also cost effective manner while reducing dependence on import of fossil fuels, thereby, providing a higher degree of National Energy Security.

The Policy also envisages development of more efficient biofuel conversion technologies for next generation based on new feedstock. The goal of the Policy is to ensure that a minimum level of biofuels become readily available in the market to meet the demand at any given time. An indicative target of 20 per cent blending of biofuels, both for bio-diesel and bio-ethanol, by 2017 is proposed. The focus for development of biofuels in India will be utilize waste and degraded forest and non-forest lands only for cultivation of shrubs and trees bearing non-edible oil seeds for production of bio-diesel (National policy for biofuels:
http://mnre.gov.in/file-manager/UserFiles/biofuel_policy.pdf).

Cultivators, farmers, landless labourers, etc. will be encouraged to undertake plantations that provide the feedstock for bio-diesel and bio-ethanol. Corporates will also be enabled to undertake plantations through contract farming by involving with farmers, cooperatives and Self Help Groups (SHGs), etc., in consultation with Panchayats, where necessary. Such cultivation of plantation will be supported through a Minimum Support Price (MSP) for the non-edible oil seeds used to produce bio-diesel.

Employment through plantations of trees and shrub bearing non-edible oilseeds will be made eligible under the National Rural Employment Guarantee Act (NREGA). A major thrust would be given through this Policy for innovation, research and development and demonstration in the field of biofuels. Research and development will focus on plantations, biofuels processing, and production technologies, as well as on maximizing efficiencies of different end-use applications and utilization of by-products (National policy for biofuels:
http://mnre.gov.in/file-manager/UserFiles/biofuel_policy.pdf).

Alternberg et al (2008) expresses his views on biofuel production in India in three different ways. First, there is a broad consensus in India that biodiesel production should be restricted to non-edible oils to avoid price increases in cooking oils. Second, the focus on land not used for intensive agriculture also contributes to minimizing the competition between fuel and food. Although biodiesel plantation on agricultural land is an option but there is a large potential to integrate oil bearing trees into farming systems and rural countryside without replacing food crops. Third, the biodiesel activity can even improve food security as it provides additional income opportunities for poor people, thereby, increasing their capacity to reinvest the money in food production or to buy the needed food. In India, 175 million hectare (ha) of wasteland is available and out of that 35 million ha can be brought under cultivation of high yielding tree-borne oil seeds such as Jatropha (*Jatropha Curcas*), Mahua (*Maduca Longifolia)*, and Pongemia (*Millettia Pinnata*) and this could make a significant contribution towards energy security.

Prospectus and Challenges of Biofuel in India

Biofuels are globally considered as sustainable and an eco friendly source of energy to enhance national energy security and reduce dependence on imported fossil fuels[6]. One major reason why biofuels have attracted so much attention in recent years among the analysts, commentators, and observers of global food policy is direct connection with food and feed availability and the subsequent influence on market prices (Trostle, 2008). Recent data suggest that a significant amount of food grains is being diverted for biofuel production by many leading producers in the world. In terms of area, nearly 47.8 million hectares of arable land was set apart for growing biofuel feedstock in 2006-07, that is nearly 3.4 per cent of the total arable land available for cultivation in the world. Because of these reasons, the growth in biofuels production is believed to be one of the major contributors to the rising food prices in the international markets. In concurrence with the official biofuel policy, India produces biofuels only from non-edible feed stocks and animal fats (Trostle, 2008). Currently, Jatropha, is the major feedstock for biodiesel in India and occupies only around 0.5 million hectares of low quality 'wastelands' across the country, of which 65-70 per cent are new plantations.

The Department of Land Resources under the Ministry of Rural Development, GoI, has estimated that around 25 million hectares of fallow land is available in the country that can be diverted for growing of feedstock crops, including Jatropha. Around 20 biodiesel plants annually produce 140-300 million litres of biodiesel which is mostly uti-

6 http://biofuelsandthepoor.com/biofuels-in-india-future-challenges/ accessed:05.01.2012

lized by the informal sector locally for irrigation and electricity generation and also automobile and transportation companies for running their experimental projects (USDA, 2010). Similarly there are no specific markets for Jatropha seed supply and hence the middlemen play a major role in taking the seeds to the processing centres which inflates on the marketing margin. The processing industry suffers from low backward integration with the seed market and forward integration with biodiesel distribution channels.

Biofuel and Food Security: A Challenge

The natural question arising from the diversion of arable land from food production to bio-energy crops. Likewise biofuel proponents is already a vocal about 'lobby of biofuel', and argue that bio- energy crops should only be grown on degraded or wasteland and not on fertile land (Sahai, online). But if the wasteland is capable of supporting Jatropha cultivation, should not be used for the cultivation of selected cereal or oilseed crops, or if not that, then fodder grasses? India and all of South Asia have large livestock populations which serve as additional support for local food security. If the region is deficient in fodder availability and all kinds of non arable land should be diverted to fodder grasses (Sahai, online).

Critics fear that the growth of the agro-fuel sector and it will be detrimental to food production (Sahai, online). As of now the impact on food prices by diverting food crops into ethanol production is reflecting. Beijing is slowing down China's ethanol production drive after increase in corn prices worldwide prompted concern about inflation and food security at home. China is manufacturing 1.2 million tonnes of ethanol from corn and wheat feedstock and ranked as the world's number three ethanol producer, after the US and Brazil. A report prepared by the World Food Organization (WFO) and the OECD predicts that the current trend will acquire land which is allotted for food production and increase the price of commodities such as sugar, maize and palm oils. This report anticipates that this will lead to a rise in food prices over the next ten years. While higher food prices will be profitable for food exporting countries and large farmers and threaten the economies of food importing countries and the livelihoods of their farmers, as well as availability of food. Similarly, India should review its biofuel policy and examine the drawbacks of proposed strategies about producing bioenergy.

Socioeconomic and Ecological Consequences of Biofuel in India

The main social drivers for the implementation of biofuel production are employment creation and regional growth. There are challenging opportunities during biofuel production, collection, transport and distribution as well. Employment generation is an important driver in developing countries to promote second generation biofuels (Vidhosh et al., 2011). A large number of constraints regarding the social impact of feedstock production is the occupation of arable land for bio energy crop and also competition with current agricultural production (Anselm, 2010). It has been evaluated that *Jatropha Curcas* and *Pongamia Pinnatta* would be suitable in Indian conditions in terms of energy production. But the main economic criteria are the total cost input on capital investment, manufacturing and biodiesel break-even price for biodiesel production. Severeal researchers applied many economic criteria to emphasize in different points of view to assess the biodiesel production. Then they found it's difficult to cultivate due to total cost involment in production operation directly as well as indirectly and so on so forth.

Government-centred cultivation can have different implications on income, employment generation empowerment environment and food security. Through the establishment of Self Help Groups (SHGs) or similar community formations, government-centred cultivation has the potential to empower the marginalized groups. This approach exists in all most all parts of India. Joint Forest Management Committee (JFMC) has the potential to empower their members because they encourage the self-management of plantations and self-organization. Besides, labour wages, sale of seeds is the main source of income for the beneficiaries. But prices are too low, people will not involve in collection of the seeds (Altenberg et al., 2008).

Multiflied oil prices in the global market and variations in the climatic conditions have paid the attention on producing environment friendly bio energy. At the same time intended the eradication of rural poverty by generating livelihood opportunities such as employment and additional household income. Thus, the Government agencies as well as policy makers have implemented the bio energy in India. In 2008, GoI adopted a national level unified policy on biofuel utilization consisting of 20 per cent biofuel blending mandate but this policy was soon withdrawn due to a serious criticism due to a lack of understanding about the economic impacts of the policy (Vidhosh, et al., 2011).

The use of biodiesel in engines brings environmental benefits, such as a reduction in the emission of Particulate Matter (PM), Hydro Carbons (HC) and Carbon Monoxide (CO), in addition to reduction in the

emission of Carbon Dioxide (CO_2) which is a significant element of the greenhouse gas effect. The smoke density and CO emissions will be reduced with the use of all biodiesel blends with respect to that of the neat diesel fuel. As an international debate Biofuels will benefit in reducing global warming and also reduce emissions of greenhouse gases.

Can Biofuel be a Solution for Climate Change?: Biofuels are the low-carbon energy source that could fill some of the gap left by depleted petroleum supplies and help mitigate the effects of climate change (Parkinson, online). Converting native ecosystems to biofuel crops creates a large carbon debt during the process of release of CO_2 from land use changes and takes time to pay back through the use of the biofuels that they produce (Parkinson, online). In this way biofuels are creating more greenhouse gasses than from the fossil fuels that they are meant to be replacing. Forests to biofuel crops are defeating the purpose because more CO_2 is released by cutting them down than saved by using the biofuel produced by the crops. An even worse scenario is seen where lowland peat forest areas are converted to biofuel crops (Parkinson, online). Converting biomass feedstock to biofuels is an environment friendly process. So using biofuels for transportation will be eco friendly. When we use bioethanol as fuel instead of gasoline and also it helps to reduce atmospheric CO_2 levels in three ways (Browne, 1997): such as avoid the emissions associated with gasoline; Second, allow the CO_2 content of the fossil fuels to remain in storage; and Third provide a mechanism for CO_2 absorption by growing new biomass for fuels.

Biofuel and Water: Biofuels which are made from crops require enormous amounts of water[7] which is already getting scarce. Bio energy is definitely an alternative energy for fossil fuels but it will compete with water which is required for food production. Demand on food grains around the world is doubling, at the same time, supply of water is getting a challenge. David Trouba expresses where will be the water to grow the food needed to feed a growing population, if you divert more and more water for biofuels production? According to Stockholm International Water Institute (SIWI), by 2050, the amount of additional water needed for bio energy production could be equivalent to the amount required by the agricultural sector. The biofuels are not 'the' solution but one of the solutions, and its production could be a great competitor to food production (Burke et al, online). Biofuels were superior as an idea and bad in practice (Narain, online). A gallon of ethanol may require more than 2,100 gallons of water from farm to fuel pump, depending on the regional irrigation practice in growing

7 http://www.cosmosmagazine.com/news/1542/water-biofuels-or-food accessed:04.01.2012

corn.[8] Biofuels may require more energy in production than they provide and they may not reduce greenhouse gas emissions as much as hoped. Moreover the fertilizers required to grow the crops to make the fuel may exacerbate oceanic dead zones as a result of chemical runoff into streams.[9]

Biofuel and its Market in India

The country's energy demand is expected to grow at an annual rate of 4.8 per cent over the next couple of decades (Sood, 2012). Most of the energy requirements are currently satisfied by fossil fuels – coal, petroleum based products, and natural gas. Domestic production of crude oil can only fulfil 25–30 per cent of national consumption and we import the rest from other countries. In these circumstances, biofuels play an important role in meeting India's growing energy needs. Besides, the trend of high consumption will not be limited to ethanol but biodiesel will also register a strong upsurge in consumption in coming years. Currently, ethanol dominates the Indian biofuel sector, but biodiesel will soon join the commercial stream. Emerging biofuel market in India provides an extensive information and rational analysis of the Indian biofuel market[10]. It gives a deep insight into ethanol and biodiesel markets across the country.

Since India liberalized its economy in 1991, the real growth rates of Gross Domestic Product (GDP) have remained consistently higher than 5 per cent (6.9 per cent in third quarter of 2011) and created a society that is moving in the direction of high mass consumption. The perception of the India will act upon the future global economy and changed dramatically in the past 15 years. Despite these impressive economic growth rates, more than 25 per cent of the population lives below the poverty line, with rural poverty rates at 30 per cent or more. More than 20 per cent of the national population is still undernourished (Rhoads, 2007). A continued effort on Biofuel must be made to include these segments of the population in future economic planning so that they can also access the opportunities of growth and not fall further behind.

The government needs to take confidence building measures and should formulate it's policy and explain to depended farmers about their role and it is vitally important in the success of the biodiesel programme (Singh, online). Financial assistance should be given to Non Governmental Organizers (NGOs) in developing a large-scale awareness/training programme for ground level farmers. The government

8 Study: Biofuel threatens water supplies available at http://www.livescience.com/3487-study-biofuel-threatens-water-supplies.html accessed: 04.01.2012
9 Note 4, page 9
10 http://www.rncos.com/Report/IM124.htm: accessed: 05.02.2012

should arrange tours for highly regarded NGOs and progressive farmers to other countries/states to enable them to witness the success of biodiesel productions.

One influential variable in the future growth of this booming economy is the energy sector. Meeting the demand for energy for residential and commercial needs will prove challenging. With the demand for transportation fuel growing at the rate of 6.8 per cent a year, it is projected that by 2020, India will become the third-largest consumer of transportation fuel in the world, after the United States and China (Rhoads, 2007). The number of vehicles on the road jumped from 20 million in 1991 to 50 million in 2000 (Rhoads, 2007).

Conclusion

Cultivation of biofuel crops is a complex issue because it is associated with many challenging tasks such as water and food insecurity for growing population, at the same time conversion of fertile agricultural area into non agricultural area. Undoubtedly biofuel is an alternative and substitute energy for fossil fuel and also minimize the GHGs emissions which result in global warming. The benefits from biofuel production is minimum and takes longer time to get the income and it will be difficult to the rural poor, particulary to small and marginal farmers. The fact that Jatropha (3 to 4 years), Pongamia (6 to 8 years), and other perennials have a longer maturation phase and the amount of income generation may not execute the needs of the day to day living expenses. Obviousely biofuel cultivation is not a labourious job and benefit minimum in longer run. The big landholder may think of it but not the other category of the farming community. Besides, it provides commodities like fuel wood, timber, thatching material for home roofing etc. Converting native ecosystems to biofuel crops creates a large carbon debt during the process of landuse change and release CO_2 and takes time to pay back through the use of the biofuels that they produce. In this way biofuels are creating more greenhouse gasses than from the fossil fuels that they are meant to be replacing. Forests to biofuel crops are defeating the purpose because more CO_2 is released by cutting them down than saved by using the biofuel produced by the crops. Cultivation of bio fuel crops shrinks the grazing land which is a food court for livestock.

The Government of India is currently discussing a National Biofuel Policy for implementation of biofuels. During this process, the government needs to take up confidence building measures and clearly formulate its policy, and also explain to farmers that their role is vitally important in the success/failure of the biodiesel programme. Department of Land Resources under the Ministry of Rural Develop-

ment, GoI, has estimated around 25 million hectares of fallow land is available in the country that can be diverted for growing bio fuel. But, there are no specific markets for Jatropha seed supply. Hence, the middlemen play a major role in taking the seeds to the processing centres and this inflates the marketing margin. The processing industry suffers from low backward integration with the seed market and forward integration with biodiesel distribution channels. No doubt biofuels are the low-carbon energy source that could fill some of the gap left by depleted petroleum supplies and help mitigate the effects of climate change. It is good as an idea, bad in practice, and may require more energy during production than they provide. Therefore, integrated management for biofuel production is essential and it should consider the importance of water, food and energy during the implementation.

References

Altenburg, T., H. Dietz, M. Hahl, N. Nikolidakis, C. Rosendahl, K. Seelige (2008). Biodiesel policies for rural development in India. German Development Institute.

Browne, J. (1997). Our Changing Earth, Our Changing Climate. The Council of Foreign Relations in New York. (http://www.nrel.gov/docs/fy99osti/24052.pdf)

Burke, J., Kuylenstierna, J. (online). The water variable – producing enough food in a climate secure world. Perspective on water and climate change adaptation. (http://www.worldwatercouncil.org/fileadmin/wwc/Library/Publications_and_reports/Climate_Change/PersPap_05._Producing_Enough_Food.pdf)

Muller, S. (2010). National dry mill corn ethanol survey. University of Illinois, Chicago. (http://www.ethanolrfa.org/pages/ethanol-facts-environment/)

Nan Shi, N., Chen Yu, D., Li, H., Songxu, W. (2009). Introduction of Biofuels. EEP 142.

(http://are.berkeley.edu/~sberto/Introduction2Biofuel.pdf accessed:31.12.2011)

National Policy on Biofuels. (online), Ministry of New and Renewable Energy, Government of India (http://mnre.gov.in/file-manager/UserFiles/biofuel_policy.pdf)

Narain, S. (online). Good idea, bad practice. (http://www.business-standard.com/india/news/sunita-narain-biofuel-good-idea-bad-practice/282155/)

Parkinson, M. (online). Biofuels, Part of the Solution to Climate Change Or Are We Being Mislead?

(http://www.newcastle.edu.au/Resources/Research%20Centres/TFI/Publications/33%20Matthew%20Parkinson.pdf accessed 31.12.2011)

Prabhakar, S. V. R. K., M. Elder, (2010). Not all biofuels are bad: A rural India case. OurWorld 2.0.

Rajgopal, D. (2002). Rethinking Current Strategies for Biofuel Production in India. Energy and Resources Group, University of California, Berkeley

Roads, J. (2007). Biodiesel and India's Rural Economy. Per Pinstrup Andersen (globalfoodsystem@cornell.edu) and Fuzhi Cheng Cornell University.

Sahai, S. (Online) Biofuel and Food Security.

https://docs.google.com/viewer?a=v&q=cache:pdoElOKIsL4J:www.genecampaign.org/Publication/Article/AG-Food, accessed:31.12.2011.

Shinoj, P., S. S. Raju, R. Chand, P. Kumar, S. Msangi, (2011). Biofuels in India: Future Challenges. Policy Brief. NCAR, New Delhi.

Singh, V.P. (online). Indian biofuel scenario: An assessment of science and policy. (http://www.climate-leaders.org/wp-content/uploads/indianbiofuel-vijaipsingh.pdf accessed 30.12.2011)

Sood, P.R. (2012). Bioethanor – A viable answer to India's surging energy needs. World Academy of Science, Enggineering and Technology, 68.

Trostle, R. (2008). Global agricultural supply and demand: Factors contributing to the recent increase in food commodity prices/ WRS-0801. *A Report from the Economic Research Services*. United States Department of Agriculture, Washington DC.

USDA (2010) India, Biofuels Annual, 2010. *GAIN Report* IN 1058. United States Department of Agriculture, Foreign Agricultural Service, New Delhi.

Vidosh, M., V. Praksh, C. Alok, (2011). Impacts of Bio-fuel use: A Review. International Journal of Engineering Science and Technology (IJEST). Vol.3. No.5.