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Biofuel Promotion in India for Transport: Exploring the Grey Areas

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Introduction

India happens to be the world's fourth largest energy consumer and a consumer of crude and petroleum products after the United States, China, and Japan.[1] The net oil import dependency of India rose from 43 per cent in 1990 to 71 per cent in 2012[2] that resulted in a huge strain on the current account as well as the government exchequer. Transport sector accounts for the largest share (around 51 per cent) in terms of consumption of petroleum products in India. Nearly 70 per cent of diesel and 99.6 per cent petroleum are consumed by the transport sector[3] and the demand is expected to grow at 6–8 per cent over the coming years in tandem with the rapidly expanding vehicle ownership. Evidently, India's energy security would remain vulnerable until alternative fuels based on indigenously produced renewable feedstock are developed to substitute or supplement petro-based fuels (Government of India, 2008).

A number of alternative energy options coupled with various initiatives towards energy efficiency improvement and energy conservation are being promoted in India to deal with an impending crisis. Among the portfolio of renewable energy alternatives that are available, biofuels, especially ethanol and biodiesel (refer to Box 1 for taxonomy), have emerged as a preferred option, especially for the transport sector in India. The objective is to reduce dependence on imported crude oil in order to enhance the country's energy security. The other reasons behind promotion of biofuels in India include climate change mitigation through reduced greenhouse gas (GHG) emission, environmentally sustainable development, and generation of new employment opportunities (Government of India, 2008).

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[1] http://www.eia.gov/countries/cab.cfm?fips=in (last accessed on October 22, 2014)
[2] http://www.eia.gov/todayinenergy/detail.cfm?id=17551 (last accessed on October 22, 2014)
[3] http://pib.nic.in/newsite/PrintRelease.aspx?relid=102799 (last accessed on October 22, 2014)

BOX 1: TAXONOMY OF BIOFUELS

Biofuel is a generic term that refers to fuel derived from biomass, such as plants and organic wastes. The International Energy Agency (IEA) adopts a simplified classification of biofuels based on the maturity of the technology deployed. This taxonomy uses terms like "conventional" and "advanced" to distinguish between different types of biofuels.*

Conventional biofuels, i.e., the first generation biofuels, include sugar- and starch-based ethanol, oil-crop based biodiesel and straight vegetable oil, as well as biogas derived through anaerobic digestion. The technology for conventional biofuel is well-established and is being deployed for producing biofuels on a commercial scale. The most common conventional biofuels that are largely used as transport fuels are ethanol and biodiesel. Both ethanol and biodiesel are used in internal combustion engines either in its pure form or more often as an additive.

Advanced biofuels, i.e., the second- or third-generation biofuels, include biofuels based on feedstock like lignocellulosic biomass, which include cellulosic ethanol, biomass-to-liquids diesel, and bio-synthetic gas. The category also includes novel conversion technologies, such as algae-based biofuels and the conversion of sugar into diesel-type biofuels using biological or chemical catalysts, and biofuel produced from conversion of agricultural residues. The technologies deployed for producing advanced biofuels are still in the research and development (R&D) or demonstration stage.

Note: *IEA, 2011.

Biofuel industry is yet to fully mature in India and it is difficult for the industry to sustain without subsidies, fuel mandates, or other government support. As biofuels are usually regarded as cleaner and greener alternatives to fossil fuels, the design of the subsidies and other policy supports to the sector is also generally done by keeping the potential positive benefits in view. However, recent scholarly studies based on Life Cycle Analysis (LCA), have cast serious doubts on the potential positive spill overs of biofuels on the environment. A number of studies have also found biofuels to be a major cause of worldwide food price inflation—attributable primarily to the integration of oil and energy markets with markets for agricultural commodities. These studies have cautioned that biofuels could exacerbate food insecurity, lead to water shortages, aggravate water pollution, increase GHG emissions through land-use changes, and add to other indirect environmental costs, adversely affect biodiversity, and so on. Serious doubts have also been raised on the parameter of net energy consumption of biofuels, i.e., whether biofuels consume more energy than they actually produce. Some recent LCA studies carried out in India have only reinforced this uncertainty with respect to net energy consumption, GHG emission, and other environmental impacts of biofuels.

Against this backdrop, the policy brief makes an attempt to provide a more realistic assessment of the pros and cons of the promotion of biofuels in India, especially in light of the interests expressed by the new government to go ahead with more aggressive promotion of biofuels. The structure of the policy brief is as follows: It provides an assessment of biofuel initiatives and policies in India in retrospect and infers on whether the policies have actually been effective to reduce India's dependence on imported crude oil. It assesses the ability of biofuels in enhancing the environmental benignity and social sustainability of biofuels in India. The paper concludes with a set of policy remarks.

Policies and Initiatives for Biofuels in India: An Assessment

Back in September 2002, the Ministry of Petroleum & Natural Gas (MoPNG), Government of India came up with a notification making 5 per cent blending of ethanol with petrol by the oil marketing companies (OMCs) 'mandatory' in nine Indian states and four union territories with effect from January 2003, through its ambitious 'Ethanol Blending Programme' (EBP). A Committee on Development of Biofuels was also constituted in July 2002 by the Planning Commission and the final report was released in July 2003. The report recommended India to progressively move towards the use of biofuels. With regard to ethanol, the report called for further strengthening of the ongoing EBP.

In India, ethanol is predominantly produced from sugarcane molasses—a by-product of sugar production. Ethanol production in India, therefore, depends largely on the availability of sugar molasses, which in turn depends on the production of sugarcane. Since sugarcane production in India is cyclical, ethanol production also keeps fluctuating from one year to another, often failing to meet the optimum supply level required to meet the demand at any given point in time. Lower availability of sugarcane molasses and consequent higher molasses prices also affect the cost of production of ethanol, thereby disrupting its supply under EBP. Thus, the January 2003 target of 5 per cent blending could be implemented only partially due to unavailability of ethanol, owing to low sugarcane production in the financial years 2003–04 and 2004–05. Resurgence in sugarcane production in 2005–06 and 2006–07 led the government to revive the

5 per cent blending norm in November 2006, mandating it for 20 states and four Union Territories, subject to commercial viability. In October 2007, the government announced a 'mandatory' 5 per cent blending of ethanol with petrol across the country (except the Northeast, Jammu and Kashmir, and island territories). Even as the attainment of this 5 per cent blending target continued to remain elusive, owing to shortage in sugarcane supply in 2007–08, in October 2008, the government went ahead in pushing the bar upwards to 10 per cent, which however, never materialized. In fact, the 5 per cent blending target has yet to be accomplished successfully.

In order to augment availability of ethanol, since October 2007, the sugar industry has been permitted to produce ethanol directly from sugarcane juice. Even then adequate supply of ethanol for the EBP has continued to remain unaccomplished from time to time for a host of other reasons as well. While lack of availability of sugar molasses is a major constraint in this respect, there are other teething problems as well. Failures to set an ethanol pricing formula and procedural delays by various state governments are some of the reasons that are responsible for delayed procurement under the EBP, even in the years when there is good sugarcane production.

As per the Ministry of Petroleum & Natural Gas (MoPNG) notification (Gazette Notification G.S.R. 4(E), dated 02.01.2013),[4] oil marketing companies (OMCs) shall sell ethanol-blended petrol which has up to 10 per cent ethanol and as per the Bureau of Indian Standard (BIS) specification, 5 per cent ethanol blending has to be achieved across the country as a whole.[5] Although the benchmark price of ethanol had been fixed at ₹44 per litre and the government had made it mandatory for OMCs to blend 5 per cent ethanol with petrol, actual lifting remained unsatisfactory.

As for Biodiesel, the Planning Commission Report released in 2003 recommended launching of a National Mission on Biodiesel based on non-edible tree-borne-oils. Since domestic requirement of edible oil seeds in India is higher than its production, it was not regarded as a viable option for the country. Instead, non-edible oil came to be regarded as appropriate feedstock for production of biodiesel. While biodiesel production in India is predominantly focused on using jatropha, other non-edible tree-borne-oils, such as pongamia, karanja, and animal fats like fish oil are also being used. The Planning Commission Report proposed a target of blending 5 per cent biodiesel with high speed diesel beginning 2006–07, gradually raising it to 20 per cent in 2011–12, i.e., by the end of the 11th Five Year Plan. It was estimated that with a projected demand of 52.33 million tonnes of high speed diesel (approx. 62.38 billion litres) by 2006–07, meeting the proposed 5 per cent blending target would require 2.19 million ha of land to be brought under jatropha plantation. On the other hand, with a projected high speed diesel demand of 66.9 million tonnes (approx. 79.75 billion litres) by 2011–12, plantation of jatropha over 11.2 million ha of land would be required to meet the 20 per cent blending target. The Report estimated that around 13.4 million ha of land could potentially be made available for jatropha plantation.

The National Mission on Biodiesel was proposed in two phases. Phase I was to consist of a Demonstration Project to be implemented by the year 2006–07. As a follow-up of the Demonstration Project, Phase II, scheduled to begin in 2007, was to consist of a self-sustaining expansion of plantation and other related infrastructure with support of the government with the aim of producing enough biodiesel for meeting the 20 per cent blending target in the year 2011–12. For implementation of the Demonstration Phase (2003–07), the Ministry of Rural Development was appointed as the nodal ministry to plant jatropha in 400,000 ha of land. This phase also proposed nursery development, setting up of seed procurement and establishment centres, installation of transesterification plant, blending and marketing of biodiesel. Public and private sectors, state governments, research institutions (both Indian and foreign) involved in the programme achieved varying degrees of success in this phase. In October, 2005, the MoPNG announced biodiesel purchase policy under which OMCs would purchase biodiesel from 20 procurement centres across the country to blend with high speed diesel by January 2006. Purchase price was set at ₹26.50 per litre. However, the cost of biodiesel production turned out to be 20–50 per cent higher than the set purchase price. Consequently, there was no sale of biodiesel. While the Phase II or the self-sustaining phase of the National Mission was to bring in about 11.2 million ha of land under jatropha plantation by 2011–12 in order to meet the 20 per cent blending target, only

[4] http://petroleum.nic.in/docs/pngstat.pdf (last accessed on October 22, 2014).

[5] http://petroleum.nic.in (last accessed on October 22, 2014).

about half a million ha had actually been planted with jatropha, of which two-thirds was believed to be new plantations needing two to three years to mature.

Jatropha plantation is a subject for state (provincial) governments in India. Public sector petroleum companies and private sector firms have entered into memoranda of understanding with state governments to establish and promote jatropha plantation on government wastelands or to enter into a contract with small and medium farmers. However, only a few states have been able to actively promote jatropha plantation despite the government's incentives and encouraging policies. Smaller land holdings and ownership issues with government- or community-owned wastelands have further hindered large-scale jatropha plantation, while use of conventional low-yielding jatropha cultivars has exacerbated the supply-side constraint. The progress of the National Mission on Biodiesel has been impeded further by inadequacy in seed collection and extraction infrastructure, buy-back arrangement, capacity- and confidence-building measures among farmers and so on. The government has also made feedstock cultivation, especially jatropha, eligible for its flagship programme National Rural Employment Guarantee Act (NREGA), which provides up to 100 government-paid days of manual rural labour per year. However, the yield of jatropha, which is traditionally used by Indian farmers for fencing activities, has been below par because of suboptimal conditions and without the use of any other yield-enhancing inputs.

Given the lack of availability of jatropha seeds production, most of the biodiesel units are not operational most of the year. There are about 20 large-capacity biodiesel plants in India that produce biodiesel from alternative feedstocks such as edible oil waste (unusable oil fractions), animal fat, and inedible oils. Presently, the total commercial production and marketing of jatropha-based biodiesel in India is small, with estimates varying from 140 to 300 million litres per year. Negligible commercial production of biodiesel has impeded efforts and investments by both private- and public-sector companies. Whatever little biodiesel is produced is sold to the unorganized sector (irrigation pumps, mobile towers, kilns, agricultural usage, owners of diesel generators, etc.) and to experimental projects carried out by automobile manufacturers and transport companies and the rest is exported. However, there has been no commercial sale of biodiesel across biodiesel purchase centres set up by the Government of India, as the government biodiesel purchase price of ₹26.5 per litre was consistently below the estimated biodiesel production cost (₹35–40 per litre). Unavailability of feedstock supply, rising wage rates and inefficient marketing channels are among the major factors that have contributed to higher production costs. In view of reports which state that most biodiesel companies in India are either working at very low capacity or are idle, the government has reportedly contemplated fixing a higher price of ₹34 per litre for purchase of biodiesel through the OMCs. However, this proposal has yet to materialize.

Notwithstanding the appalling state of biofuel blending targets till date, the National Policy on Biofuels that was drafted by the Ministry of New and Renewable Energy (MNRE) was approved by the Union Cabinet in September 2008 and had set an indicative target of 20 per cent blending of biofuels—both for biodiesel and ethanol—by 2017. However, there is a provision for periodical review and modification as per the availability of biodiesel and ethanol, thereby, incorporating an element of flexibility. While the blending target for biodiesel is intended to be 'recommendatory', that of ethanol has been made 'mandatory' (Government of India, 2008).

The new Indian government has been mulling over a 10 per cent ethanol blending that is expected to reduce import of petroleum by $3 billion a year.[6]

However, as of July 2014, oil companies have been able to 'achieve' only a 1.37 per cent blending of ethanol with petrol.[7] The low blending has been attributed to competing requirements of ethanol for the liquor and chemical industry and poor responses from the sugar industry.[8,9] However, with the Cabinet Committee on Economic Affairs (CCEA) announcing a higher price of ethanol in December 2014 in the range of ₹48.50–49.50 a litre (depending on the distance between the sugar mill

6 http://www.biofuelsdigest.com/bdigest/2014/07/29/india-could-save-3-billion-in-petroleum-imports-annually-with-e10 (last accessed on October 22, 2014).

7 http://www.thehindubusinessline.com/economy/oil-firms-fall-short-of-ethanol-blending-target/article6186812.ece, (last accessed on October 22, 2014).

8 http://www.business-standard.com/article/markets/ethanol-blending-goes-for-a-toss-due-to-poor-response-from-sugar-mills-114022000964_1.html (last accessed on October 22, 2014).

9 http://www.business-standard.com/article/economy-policy/dept-of-chemicals-wants-ethanol-blending-programme-to-be-restricted-at-5-114092900558_1.html (last accessed on October 22, 2014).

and the oil market depot)[10] and with MoPNG reported to have circulated a Cabinet note for inter-departmental consultation on allowing 5 per cent blending of biofuels in diesel that would be consumed by bulk users such as the railways and defence establishments,[11] the blending situation is expected to improve and reduce India's dependence on crude oil to some extent. Given the cyclical nature of sugarcane, a periodic review of ethanol prices also becomes critical. However, resistance is coming from OMCs who have cancelled 1,200-million-litre ethanol procurement tender and are seeking a cut in the accepted price in the face of falling crude oil prices,[12] although the situation is only expected to be temporary.

Although the multi-pronged policy prescriptions for development and promotion of biofuels in India appear positive, the achievement of the targeted blending of 20 per cent by 2017 as proposed by the National Policy on Biofuels seems a remote possibility, given the existing infrastructure and the institutional set-up and other constraints. Some additional constraints are also posed by sub-national policies, the administrative controls that some Indian states have placed on free movement of biofuels across state borders, and restrictions at the district level as well which make it very difficult for biofuels to be transported across state and district borders. Another key constraint arises from differential tax structures at the state level. Given these multifarious constraints, it is quite obvious that even aggressive promotion of biofuel in blended form would be able to reduce India's net dependence on imported crude oil only marginally and thus can hardly be an apt solution to address the problem of India's energy security.

Environmental and Social Sustainability of Biofuel Promotion in India

Environmental Sustainability

Considering the environmental benignity, biofuels can influence the environment in multiple ways and are associated with various environmental impacts along the production–consumption chain. The plant (that provides feedstock for biofuel) takes up CO_2 (carbon dioxide) during its growth, which is again released when the biofuel is burnt, e.g., in a vehicle. The plant uptake of CO_2 and fuel-burning neutralize each other. However, the processes of planting, harvesting, transporting and transformation lead to GHG emissions in the life cycle of producing biofuels. These need to be compared with the life cycle emissions of conventional fuels to establish the GHG reduction due to usage of biofuels (known as life cycle analysis or well-to-wheel analysis).

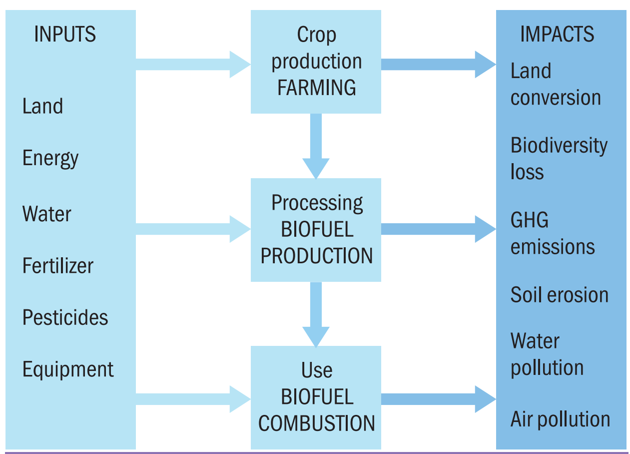
Emissions related to crop production include:

- Emissions due to energy usage in crop cultivation and harvesting
- Emissions (N_2O) due to fertilizer usage including potentially upstream emissions associated with chemical fertilizer production
- Emissions related to land-use change leading to changes in carbon stocks in carbon pools (e.g., energy crops are planted on areas formerly covered by forests).

Biofuel production related emissions include:

- Energy used in the biofuels refinery (electricity and fossil fuel)
- Methane emissions resulting from waste-water treatment facilities in the refinery.

Transport emissions include those associated with the transport of agricultural input to the biofuel refinery and the transport of the (blended) biofuel to the gas station.



Source: UNEP (2009)

[10] http://www.thehindubusinessline.com/markets/stock-markets/sugar-stocks-rally-as-govt-hikes-ethanol-price-for-blending-with-petrol/article6683318.ece (last accessed on December 16, 2014).

[11] http://articles.economictimes.indiatimes.com/2014-11-06/news/55835735_1_bio-diesel-project-bio-diesel-use-bio-diesel-association (last accessed on December 18, 2014).

[12] http://www.business-standard.com/article/companies/omcs-cancel-ethanol-procurement-tender-114120200881_1.html (last accessed on December 16, 2014).

Some of the recent LCA studies carried out in India on jatropha (*Jatropha curcas L.*)[13] deserves special mention. The study carried out by Confederation of Indian Industry (CII) in 2010 came out with a framework for estimation of energy and carbon balance of various categories of biofuels (ethanol and biodiesel) in the Indian context. The study analysed the inputs and data received from various industries, R&D laboratories, academic institutions involved in production and research of biofuels, besides referring to published data available in the public domain. It focused on four key parameters: net energy balance, net carbon balance, net energy ratio, and percentage reduction in carbon emissions.[14] Based on the analyses carried out in the report, biodiesel from jatropha oil has been observed as having favourable characteristics in terms of energy and carbon balance as compared to other biofuels. This is due to significant energy contribution from the co-products obtained during biodiesel production, namely seed husk, seed cake and glycerol, which contribute almost 48 per cent of the total energy generated during the end-use stage. On the other hand, sweet sorghum based ethanol has been observed to have the best conversion efficiency in terms of converting input energy to output energy. The CII report also estimated the GHG emissions reduction value of 30 per cent for biodiesel in comparison to petroleum diesel. Another study carried out in the Indian context by Achten in 2010, evaluated a small scale, low input based jatropha system grown on degraded land, which was unsuitable for cultivation of food crops. Although the results showed a reduction in non-renewable energy requirement (82 per cent) and global warming potential (55 per cent) in comparison to the reference system, the acidification and eutrophication[15] were observed to increase by 49 per cent and 430 per cent respectively. The land-use change, however, was triggered by shifting from degraded land to jatropha plantation.

A more recent study on LCA for biodiesel in India by S Kumar and others in 2012 was carried out to assess energy balance and the GHG emissions for production of one tonne of jatropha biodiesel (approx. 1.1 kilolitre), observed that the GHG emissions reduction with respect to petroleum diesel for generating 1 GJ energy varied from 40 per cent to 107 per cent and net energy ratio (NER) values varied between 1.4 to 8.0 depending upon the methodology used for energy and emissions distribution between product and co-products and also on whether irrigation has/has not been applied. The authors underscored that the amount of process energy consumption and GHG emissions in the individual stages of the LCA were a strong function of co-product handling and irrigation. In other words, the net savings in energy consumption and GHG emissions were clearly contingent upon the process adopted.

Additionally, some biofuel feedstocks, for instance sugarcane, which is used as a major feedstock for generating ethanol in India, require significant quantities of water, particularly in hot and changing climates. Sugarcane has water requirement of 20,000–30,000 m^3/ha/crop. This means that in the regions already experiencing water stress in India, the development of biofuels will exert additional pressure on the water systems, with likely fallout on the food chain. Large scale biofuel production consumes water and impacts water quality in a variety of ways. These impacts include: (a) use of water to grow and process feedstock into fuels; (b) release of agrochemicals into surface and ground water; and (c) change in local watershed hydrology caused by the biofuels crops. Hence, ambitious plans to scale up biofuel production will only increase water demands In other words, the fallout of biofuel production in India has a lot of uncertainty elements. Unless a full-proof sustainable process of production is adopted for large-scale biofuel production, it may actually turn out to be a bane instead of boon for India.

Social Sustainability: The Food Fuel Trade-off

Even if one presumes that biofuels do have certain beneficial impacts, it will be difficult to justify their promotion if such policies trigger diversion of land to biofuels and disincentivize production of food crops,

[13] The oil from jatropha could be easily extracted and converted to biodiesel using transesterification.

[14] The report defined these parameters as—Net Energy Balance: The energy supplied by the biofuel and its associated co-products at the end use minus the energy required during various manufacturing stages of biofuel. Net Carbon Balance: The net quantity of greenhouse gas emitted/avoided to the atmosphere during the various stages of manufacture, distribution and end use of fuel. Net Energy Ratio: The ratio of energy output obtained from the end use of biofuel and energy input used for the production of biofuel. Percentage Carbon Emission Reduction: The net quantity of greenhouse gas emissions avoided when substituting the use of petro-fuel by biofuel.

[15] Acidification potential (AP) is based on the contributions of SO_2, NOx, HCl, NH_3, and HF to the potential acid deposition, i.e., on their potential to form H+ ions. Eutrophication potential (EP) is defined as the potential to cause over-fertilization of water and soil, which can result in an increased growth of biomass (Sourced from onlinelibrary.wiley.com, last accessed on October 20, 2014).

thereby contributing towards rise in food prices—the so called food–fuel trade-off.

In India, a large section of the population still eke out a living below the poverty line and an increase in food prices is particularly damaging, since rising food commodity prices tend to negatively affect lower income consumers more than higher income consumers as lower income consumers spend a larger share of their income on food. Usually, staple food commodities such as corn, wheat, rice, etc., generally account for a larger share of food expenditures in low-income families and the food price inflation of 2006–08 was especially stark for cereals. With a reduction in food consumption due to higher prices, there could be a drastic increase in the incidence of hunger. Furthermore, consumers in FAO-classified, low income food-deficit countries, including India[16], are particularly vulnerable.

The food–fuel conflict has led to a search for alternative non-edible feedstocks that can be grown on unused marginal lands or wastelands, i.e., areas that cannot be used for growing food crops, and thus may not pose a threat to food security. In this context, India's interest has centred on jatropha, since it can be grown on wastelands and does not require much water. However, while jatropha may not need significant amounts of water to survive, it requires more water and fertilizers to increase the yield of seeds and oil. Moreover, since jatropha does better on higher quality land, so there are concerns that it may be difficult to limit jatropha to wastelands alone unless there is an appropriate regulatory framework in place. The logic of focusing on a crop that cannot be used for food solely as a way to avoid the food–fuel conflict is thus not entirely convincing. If a large market is developed for an inedible fuel crop like jatropha, there will be intense pressure to reduce costs and increase profits by cultivating it on higher quality arable land to obtain higher yields. In such a scenario, it is unlikely that it would be possible to limit its cultivation to 'wastelands' or 'marginal lands' and its cultivation may spread to better quality land and displace food crops. The extent of the so-called marginal lands or wastelands that remain unused in India is also uncertain because India suffers from intense population pressure. Ground realities may reveal that the land which may have been declared as marginal land or wasteland in the government records, is actually being used for subsistence crops or livestock grazing by poor people without secure tenure. Shifting the land to commercial uses like jatropha plantations may further disenfranchise the landless poor. Hence, the issue of classification of wasteland becomes relevant in this context. In India, for instance, various competing wasteland classifications currently exist—each using different assessment criteria. Without addressing this particular dimension in wasteland classification, the efficacy of wasteland development schemes by promoting biofuels becomes questionable. However, additional clarity in wasteland assessment may not necessarily improve the welfare impacts of wasteland development. On the contrary, such clarity could actually end up hastening the land-grab that is occurring in rural India. For instance, field studies carried out in the South Indian state of Tamil Nadu reveal that, being motivated by the Indian policy to restrict feedstock cultivation to waste and marginal lands, biodiesel companies have slowly been amassing plantations of privately owned 'wastelands'—the Indian government's term for marginal lands—by purchasing lands from farmers at low rates and/or re-registering farmer's lands without their knowledge or consent. It has been further observed that after short-lived attempts at raising biofuel plantations and very likely after receiving government subsidies for seedling procurement and land preparation, the companies are in the process of selling lands into real estate for at least double the purchase price per acre. Thus, instead of minimizing threats to food security and enhancing rural welfare, growing biofuels on marginal and wastelands are allegedly doing the exact opposite by dispossessing farmers of their land.

A more recent study carried out by Singhal and Sengupta in 2012, has also found that in jatropha plantations, Indian farmers incur higher paid-out expenses, thus restricting the potential benefits of the development of an agro-based energy producing industry to only the section of the farming community who have access to credit at a reasonable cost. Additionally, the establishment of jatropha monocultures was often unwelcome, primarily because what official statistics regard as 'marginal lands' are often under some form of traditional use by rural populations, be it shifting cultivation, pastoralism, or use for other resources such as fuel wood and medicinal plants. The farmers who could be persuaded into jatropha cultivation were

[16] http://www.fao.org/countryprofiles/lifdc/en (last accessed on December 7, 2014).

made to enter into buy-back contracts but were largely abandoned when yields proved disappointing. This led to a reduction in local food production (for instance, groundnut in the state of Tamil Nadu), larger vulnerability to food insecurity coupled with a number of social and economic costs that the rural poor were not ready to bear.

Concluding Remarks

An important criticism that has been levelled against the biofuel policy in India is that it has largely been sugarcane-centric which goes against the idea of utilizing degraded and less fertile land for biofuel production. This is also the likely cause of the current battle for alcohol between the liquor, chemical, or medicinal industry and the biofuel industry. This is coupled with the fact that sugarcane happens to be a big beneficiary of subsidies on fertilizer, pesticide, and electricity for irrigation. Another study carried out by Raju and others in 2012 further indicates that if the government is to achieve the target blending of 20 per cent as proposed in the National Biofuel Policy by the year 2016–17, a production of approximately 736.5 million tonnes of sugarcane with area coverage of 10.5 million ha would be required. This essentially translates into doubling both the production and the area under sugarcane. However, given the current trends in yield and area growth, achieving the blending target appears highly unlikely without significant imports of ethanol that clearly goes counter to the idea of reducing dependence on imported energy sources for a net energy and crude oil importer like India. An alternative route could be explored by improving the efficiency of ethanol recovery through direct conversion of sugarcane juice to ethanol but that could reduce sugar production with potentially adverse implication on market prices of sugar and hence does not appear to be pragmatic. This clearly demands a focus of the biofuel policy on diversifying towards alternative sources of sugar and ethanol such as sweet sorghum, tropical sugar beet, etc., which are less resource-intensive and sustainable as compared to sugarcane.

Another related issue in this context that has been discussed is whether there is enough available wasteland in India to significantly increase first-generation biodiesel production, without any potential impact on food production. It is also an open question whether biofuels can be developed sustainably in India without raising GHG emissions or avoiding other adverse environmental implications. Going by the findings of the LCA studies carried out in India, environmental implications of biofuels remains contentious. Furthermore, sugarcane, the main feedstock for current ethanol production in India, is highly water-intensive, as explained before. Given the complexity of direct and indirect impacts of biofuel expansion on land, water use and biodiversity, defining sustainability in an all-encompassing manner is extremely challenging for a country like India with its demographic, socio-economic, human development, and governance challenges.

While the need for the diversification of energy resources for producing biofuels in India is absolute, it is quite obvious that the contribution that conventional or first generation biofuels can make to enhance energy security is physically very limited, and does come at a considerable financial cost. As biofuel industry is yet to mature, it may be challenging for the fuel to emerge as a cost-effective alternative to fossil fuels without adequate subsidies and other policy incentives. Second generation or advanced biofuels are being mooted as appropriate alternatives to address the challenges posed by the promotion of first generation biofuels. Technically speaking it may be possible to produce a large proportion of transportation fuels using advanced biofuel technologies, specifically those that can be grown using a small share of the world's land area (e.g., microalgae), or those grown on arable lands without affecting food supply (e.g., agricultural residues). However, a number of barriers limit the near-term commercial application of advanced biofuel technologies. These barriers include low conversion efficiency from biomass to fuel, limits on supply of key enzymes used in conversion, large energy requirements for operation, and dependence in many cases on commercially unproven technologies, among others. Hence, despite huge future potential, large scale deployment of advanced biofuel technologies is unlikely in the near future, unless further research and development lead to a lowering of these barriers.

Although, in view of the sustainability advantages of advanced biofuels *vis-à-vis* conventional biofuels, the former is often regarded as a 'cleaner and greener' option. However, the questions still remains as to whether any energy source produced on a large scale, or without sufficient care, could avoid the risks of adverse environmental fallouts. For instance, the removal of agricultural residues may have impacts on biodiversity, because of changed habitat functions like shelter, fodder source, or nesting places. The export of agricultural residues from the field means a loss of organic material, which influences the fertility balance of the soil. The reduced soil coverage may also lead to a change in the humidity regulation of the soil and reduced protection of evaporation and erosion due to wind and precipitation. Furthermore, GHG emissions might occur through soil carbon changes when extracting residues, as well as due to the use of fertilizers and diesel caused by straw removal. Even algal biofuels, just like crops, require land, water, fertilizers, pesticides, and inputs that are costly. It would, therefore, be crucial to realize that, on a life cycle basis, some advanced biofuels can even generate higher levels of GHG emissions and can have more negative impacts on land and water use—as well as biodiversity and local livelihoods—than some conventional biofuels. So, advanced biofuels, if produced unsustainably, may not necessarily be able to resolve the problems that are currently being encountered with first generation biofuels. MoPNG has reportedly moved a proposal for the Cabinet to allow blending petrol with cellulosic ethanol produced from biomass such as switch grass, paper pulp, sawdust, municipal waste, and non-edible parts of plants[17]. Although the policy is expected to reduce dependence on sugarcane and would resolve the battle between the biofuel industry and other competing industries, it would obviously have its own set of challenges.

To sum up, biofuels, whether conventional or advanced, should not be regarded as a silver bullet when it comes to addressing the problem of energy security, environment, and society in India. They should not be the exclusive or even the main focus of climate change and energy policy in India but should ideally be placed in the context of a comprehensive energy policy, which includes promoting energy conservation and efficiency as well as the promotion of other renewable energy alternatives.

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