Rethinking Current Strategies for Biofuel Production in India

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Abstract

Economic, environmental and energy security concerns arising from reliance on petroleum are forcing countries the world over to shift to alternatives ethanol and biodiesel. Since biofuels can be produced from a diverse set of crops each country is adopting a strategy that exploits the comparative advantages it holds in certain crops. India has launched a National Mission on Biofuels, the main strategy of which has been to promote Jatropha Curcas; a perennial shrub that bears non-edible oil seeds that can be used to produce biodiesel. The cultivation of Jatropha Curcas is to be undertaken mostly on wastelands. The purpose of this paper is to argue that the India's biofuel policy has certain drawbacks. These include the dependence of the rural poor on such wastelands for diverse purposes and which are unlikely to be met by Jatropha plantations, the potential for conflicts from the appropriation of common pool resources like wastelands without involvement of local communities in decision making, the lack of prior experience with cultivation of Jatropha especially on marginal lands, government subsidies to growers who would mostly be large landholders, the absence of minimum support prices for biofuel crops etc. An alternative approach would be one which focuses on multi-purpose, short-duration annual crops that can either simultaneously yield fuel along with food and/or fodder or can be cultivated in rotation with food crops, so that even small private farmers can benefit from the opportunities that the market for biofuels present. Some crops that are already commercially well known and can be scaled up to produce for bioenergy are also discussed. The importance of policies like renewable fuel standards and minimum support prices for biofuels is also emphasized.

I. Introduction

Economic, environmental and energy security concerns resulting from excessive reliance on petroleum are forcing countries the world over to shift to alternatives like biofuels in the form of ethanol and biodiesel [8]. Since biofuels can be produced from a diverse set of crops each country is adopting a strategy that exploits the comparative advantages it holds with respect to such crops. For example, the sugarcane and maize are the main feedstock for ethanol in Brazil and US respectively, while the production of biodiesel in Malaysia is from oil palm. The Government of India (GoI) has launched a National Mission on Biofuels with the aim of achieving a target of 20% blending of biodiesel by 2012 [10]. It should be pointed out that such a target has however not been mandated by law and is merely indicative of government preference at this point. Apart from reducing the dependence on imported fuels, the mission aims to generate several other benefits like employment generation for the rural poor, regeneration of wastelands, reduction of emissions resulting from energy use that can lead to positive economic and environmental change. The aim of this paper is assess whether such benefits can indeed result from the current strategies of the biofuel mission.

Salient features of the Current Strategies for Biodiesel Production

The main aim of the mission is to produce enough seed material for production of biodiesel so as to achieve the target of 20% blend by 2011-2012. It aims to bring around 400,000 hectares of marginal land under cultivation of non-edible oil seed crops. The production of oil seeds is to be primarily from a perennial shrub called Jatropha Curcas. Apart from reducing the dependence on oil imports, the other major benefits are said to be rural poverty alleviation through employment generation and environmental benefits of regeneration of wastelands. The schemes are aimed at primarily benefiting small farmers and the landless poor. Subsidies are to be provided to cover cost of cultivation during the initial years of growth of crop.

The paper is organized as follows. Section 2 describes the drawbacks in the current approach. Section 3 presents some potential alternative strategies for biofuel production and regeneration of wastelands. Section 4 presents the summary and conclusions

II. Drawbacks in Current Strategies

This section describes some the principal drawbacks of current strategies.

1. The use of common property lands for Jatropha plantations and implications for the poor

Due to scarcity of agricultural land and the need for vast amount of land for cultivation of biofuel feedstock, biofuels crops are considered a threat to both food production and forests. The recent rise in price of corn in the US and the expansion of oil palm plantations at the expense of rainforests in Malaysia can be cited in support of such claims. As if in recognition of this fact and the fact that India has vast resources of marginal land also called wasteland, which are considered to provide little economic or ecological benefits, the national biofuel mission emphasizes cultivation of biofuel crops on such lands. However several researchers have contested the categorization of such lands as wastelands on the grounds that such lands are an integral part of the livelihood of rural poor.

A majority of such wastelands are classified as common property resources (CPR). This implies that a group such as a village collectively owns such resources and membership in the group confers an individual the right to access the resource. Research on CPRs has revealed that such resources play a vital role in the lives of its users by supplying a wide variety of commodities like food, fuel wood, fodder, timber, thatching material for home roofing etc [11,16]. Gundimeda cites evidence from several studies [3, 13, 14] on CPRs in arid and semi-arid regions of India that show: (1) CPRs contribute between 12 per cent and 25 per cent of the poor household income; (2) the poorer the households, the more important the contribution of CPRs; (3) CPRs contribute to rural equity because they are accessed more by the poor than by the rich. Therefore the composition of tree species planted on wastelands lands is very important as disregard for rural needs such as those above is likely to cause hardship to the poor and to conflicts with growers of biodiesel or other plantations on such lands.

Jatropha has several drawbacks in this context. First, the leaves of Jatropha are not suitable for livestock i.e., not suitable as fodder. The situation with regard to the severe shortage of fodder for livestock has infact been deemed the "other food crisis" [5]. In this context plantation of Jatropha on common lands, which are often grazing lands, is likely to worsen the fodder crisis. Second, Jatropha yields insignificant amount of wood per tree. A case study of a Gujarat village showed that the poor collect 70 per cent of their fuel and 55 per cent of their fodder requirements from CPRs [4]. Thus policies, which promote crops that provide diverse benefits, would have much less adverse impact on the rural poor.

2. The limitations of dependence on Wastelands

According to the Department of Land Resources (DoLR)[1], GoI, about 63.9 million hectares of land is lying waste in India mainly because they are unsuitable for cultivation in their present state. Although collectively considered waste they are heterogeneous with regard to their physical and socio-economic characteristics. The GoI has categorized the wastelands as shown in Table 1.

Table 1

	Category of wasteland	Area (million .hec)	% of total wasteland
1	Snow Covered/Glacial	5.6	9%
2	Barren Rocky/Sheet Rock	6.5	10%
3	Sands-inland/coastal	5.0	8%
4	Land affected by salinity/alkalinity	2.0	3%
5	Gullied/or ravinous land	2.1	3%
6	Upland with or without scrub	19.4	30%
7	Water logged & Marshy	1.7	3%
8	Steep sloping area	0.8	1%
9	Shifting cultivation land	3.5	6%
10	Mining/Industrial Wastelands	0.1	0%
11	Degraded/pastures/grazing land	2.6	4%
12	Under utilised/degraded notified forest land	14.1	22%
13	Degraded land under plantation crop	0.6	1%
	Total	64	100%

Source: http://dolr.nic.in/wasteland.htm

However among the total amount of land only three categories, namely, degraded pastures and grazing land, under utilized degraded notified forest land, and degraded land under plantation crop categories (#11, #12 and #13 in the table above) comprising about 17 million hectares is considered to have the potential for cultivation with crops like Jatropha. This is because the main reason for the current state of such lands is overgrazing and overexploitation as opposed to inherent abiotic stress from the environment. In other words, wastelands characterized by sandy soils, rocky soils, saline soils, sloping terrains, snow-covered areas etc. represent an exogenous stress which can be overcome only by planting crops that have either adapted or been specifically bred to adapt to such conditions. There is little scientific evidence to suggest Jatropha can bear

[1] http://dolr.nic.in/wasteland.htm.

fruits under such diverse conditions. A survey of thirty-eight different studies on the economics of reclamation of wastelands by Balooni concludes that afforestation either with existing natural root stock or using specially adapted crops like *Acacia Nilotica*, *Prosopis Juliflora*, *Casuarina Equisetifolia*, *Sesbania Egyptia*, and various *Eucalyptus* species are financially viable based on the yield of fuel wood, fodder, timber, and other forest produce [2]. Most of these studies do not even include environmental benefits in the accounting models and still find a positive return on investment. That is to say there exist several competing crops and uses for wastelands. Hence economic estimates of Jatropha plantations are incorrect in assuming zero opportunity cost for wastelands. There are no reliable estimates to suggest that the BCR for Jatropha and Pongamia plantations outweigh that for other afforestation options. The essential point here is that while the wastelands represent a vast untapped land resource there is little reason to believe that more than 10% of the total wasteland resource (about 1/3rd of the land under categories 11, 12 and 13) could be commercial viable as Jatropha plantations. In addition due to the poor soil condition, marginal lands cannot support high plantation density without adversely affecting output per plant. Therefore yield per hectare from such lands is likely to be lower compared to yield from lands of higher quality.

3. Current status of technology on Jatropha

Although Jatropha Curcas may have the potential to grow in diverse agro-climatic conditions, withstand drought and pest attacks, there is bound be accompanying variation in important parameters like seed yield, oil content, nutrient requirements etc. which are critical to economic viability of plantations. The survey carried out by the National Oil-Seeds and Vegetable Oil Development Board is said to have reported variation in oil content ranging from 21% to 48%. There is also no scientific evidence on the absence of pests and diseases in Jatropha plantations. In fact cultivation practices reported by Tamil Nadu Agricultural University, Coimbatore (TNAU) mention of pests like defoliators, bark eaters, stem borers etc., which call for pest management techniques[2]. Further high plantation densities like 2500 plants per hectare are possible only under good soil and water conditions while on rain-fed plantations on marginal soils optimum density is said to be about 1600 plants per hectare. The resulting effect is that production per hectare is likely to be lower on such lands. Such wide variation in key economic parameters and the lack of standardized seed material, cultivation practices call for intensive research and development prior to a large-scale planting based on incomplete information.

4. The need for timely irrigation during initial years on growth and yield

One of the major reasons for selection of Jatropha is its low water requirement and therefore its suitability to dry and arid lands. It may be true that perennial crops are better adapted to withstand long spells of dry weather compared to short duration crops, however even trees require well-spaced irrigation especially during the initial few years of development barring which their growth and productivity is permanently affected. Numerous scientific studies on horticultural crops have shown that irrigation regime has a

[2] http://www.tnau.ac.in/tech/swc/jatropha.pdf

significant positive impact on both yield and quality of fruits. A study by Prayas reports wide variation in seed yield ranging from 0.4 tons/hectare to 12 tons/hectare the best yields having been reported only under irrigated conditions and intensive cultivation [15]. As if in recognition of this fact, agronomic experiments and field trials on Jatropha at institutions like the Tamil Nadu Agricultural University are being conducted under irrigated conditions. It is quite likely that fruit and hence seed production of Jatropha in dry rain-fed conditions would be below par and hence economically unviable.

5. The bias towards large farmers

Long gestation periods also do not motivate farmers to take up tree plantation adventures. The fact that Jatropha (3 to 4 years), Pongamia (6 to 8 years) and other perennials have a long maturation phase and that various uncertainties exist especially in cultivation and marketing such crops present significant barriers to adoption especially for small farmers. A study on the planting of Jatropha as part of the Horticulture program of the Employment Guarantee Scheme in Maharashtra shows that subsidies are mainly benefiting the large farmers who are the adopters [15]. This study also found that the total subsidy that was provided exceeded the cost of cultivation. Small and marginal farmers might at best benefit indirectly if they gain from new employment opportunities in the plantations of adopting farmers or if there is an increase in the price of crops displaced by Jatropha. Small farmers are also likely to be more skeptical of buy-back contracts being offered by biodiesel companies with little track record with farmers in a given region. Shorter duration crops like Sweet Sorghum and Castor are likely to offer better prospects for poor farmers especially during the initial stages of development of the biofuel industry (a more detailed discussion follows).

6. The need for Renewable Fuel Standard (RFS) and Minimum Support Prices (MSP)

While the national mission on biofuels was launched as far back as 2003, there does not as on date exist a formal policy that has been passed into law relating to biofuels. First, blending of biodiesel is yet to be mandated by law and the various missions are merely indicative of government preference. Such mandates, which are commonly called Renewable Portfolio Standards (RPS) in the electricity industry and Renewable Fuel Standard (RFS) in the transportation industry[3], have become the preferred mechanism through which national and state governments in several OECD countries guarantee a market for investments in alternative energy technologies. However since there exist no such mandates in India oil companies have little incentive to undertake the necessary investments to achieve blending of biofuels with conventional fuels. On the other hand if the existence of a guaranteed export market is adequate incentive then the premise of subsidizing the biodiesel industry for national energy security becomes untenable. Second, complementing the absence of guaranteed national market for biodiesel, is the absence of MSP for biodiesel crops. MSP for agricultural commodities perform the vital role of motivating farmers to undertake cultivation in risky environments such as those encountered by poor farmer's in arid, rain fed regions. The absence of MSP is bound to deter investments especially in long duration crops with little history of cultivation such

[3] http://www.doi.gov/iepa/EnergyPolicyActof2005.pdf

as Jatropha Curcas or Pongamia Pinnata. The past experience with farm forestry projects like Eucalyptus mission during1980s, when planting of Eucalyptus trees was undertaken is worth recollecting here. The collapse of the market for Eucalyptus trees in 1980s and the absence of minimum support prices, lead to huge losses for farmers [19]. Given this history farmers are likely to be highly skeptical of similar extension efforts at promoting Jatropha. Farmers are more skeptical of buy-back of seeds offered by private investors and likely to prefer MSP.

III. Recommendations for alternative strategies for biofuel production

In light of the above discussion some alternative options for production of liquid biofuels and for regenertion of wastelands are discussed below.

1. Alternative crops: Short-duration, multi-purpose biofuel crops on private farmlands

In comparison with wastelands, India's net-cropped area is in the vicinity of 150 million hectares out of which less than 30% is irrigated while the rest is rain-fed[4]. Farmers in rain-fed lands are amongst the most economically distressed which is largely due to scarcity of water and their inability to raise higher value crops like rice, wheat, sugarcane, edible oils etc. The cultivation of biofuel crops that are both commercially valuable and not water intensive can provide new opportunities for raising rural income without having an adverse impact on national food production or on the landless poor who depend on common lands. While Jatropha or Pongamia are suitable crops, the long maturation phase and the lack of experience are major barriers for adoption. But annual crops like Sweet Sorghum and Castor, which are already being cultivated, and which can be used to produce ethanol and biodiesel are better candidates. Such annual crops have other advantages over perennial crops such as allowing the farmers to practice crop rotation, the flexibility to shift to more profitable crops depending on market conditions etc. Since a detailed description of all the various potential crops is beyond the scope of this paper, a brief background about Sweet Sorghum and Castor is given below.

- **Sweet Sorghum:** Sorghum (*Sorghum bicolor* (L) Moench) is considered the most important crop in arid and semi-arid regions of the world. Globally, it occupies about 45 million hectares with Africa and India accounting for about 80% of the global acreage[5]. Although sorghum is best known as a grain crop, Sweet Sorghum is a close variant used mainly as livestock fodder since its high rate of photosynthesis produces leafy stalks that make excellent silage. The stalks are rich in juice, which can be processed into sugar, jaggery or distilled to produce ethanol. Therefore the juice, grain and bagasse (the fibrous residue that remains after juice extraction) can be used to co-produce a combination of food, fodder, ethanol and electricity [9]. The resistance to drought, saline-alkaline soils, to water logging has been proven by its wide prevalence in various regions of the world today [7, 18]. Given the familiarity with cultivation of sorghum the ability and willingness to adopt sweet sorghum is much higher compared to that for

[4] http://agricoop.nic.in/stats1.htm
[5] http://www.faostat.fao.org

Jatropha. The yield of biofuel per hectare per year is higher for Sweet Sorghum. The comparative advantage of sweet sorghum compared with Sugarcane is that its growing period of 4 months and water requirement of 8000 cubic metre (over two crops) are about 4 times lower than that for sugarcane (12-16 month growing season and 36000 cubic metres of water). The cost of cultivation is also about three times lower than sugarcane [18].

- **Castor**: Castor (Ricinus communis L.) is cultivated around the world because of the commercial importance of its oil which is used in the manufacture of a number of industrial chemicals like surfactants, greases and lubricants, specialty soaps, surface coatings, cosmetics and personal care products, pharmaceuticals, etc. The Indian variety of castor seed has an oil content of 48% and 42% can be extracted. The residual oil cake, which contains about 5.5 per cent Nitrogen, 1.8-1.9 per cent Phosphorus and 1.1 per cent Potassium is used as organic manure. Castor grows well under hot and humid tropical conditions and has a growing period of 4 to 5 months. Castor is grown either as a pure crop in rotation with wheat, linseed etc., or is grown mixed with cotton, groundnut, arhar, green gram, jowar, bajra and cowpea. The average yield of seed per hectare and oil per hectare is 1250 kg/hectare and 550 lit/hectare India is the world's largest producer and exporter of castor oil. It is currently cultivated on about 700,000 hectares mostly in Gujarat and Andhra Pradesh under rain fed conditions. The comparative advantage of Castor is that its growing period is much shorter than that of Jatropha and Pongamia, and there is considerably greater experience and awareness among farmers about its cultivation. Being an annual crop it gives the farmers the ability to rotate or shift away easily depending on market conditions.

2. Alternative Plantation Option for Wastelands

Although biofuels have largely come to mean liquid fuels for transportation fuels like wood, charcoal, dung and agricultural residues are currently the most important source of renewable energy from a developing country standpoint [12]. According to Bailis et al in sub-saharan Africa biomass comprise about 90 percent of the household energy use [1]. According to the 55th round of the National Sample Survey of India conducted in 1999–2000, which covered 120,000 households, 86 percent of rural households and 24 percent of urban households rely on biomass as their primary cooking fuel [20]. Biomass gasifier systems based on wood, raised on wastelands, are considered to have the largest potential to meet rural electricity needs in India. Production of woody biomass, as feedstock for power generation, can provide economic incentive to transform wastelands into energy forests [17]. As pointed out earlier afforestation of wastelands either with existing natural root stock or using specially adapted crops like *Acacia Nilotica*, *Prosopis Juliflora*, *Casuarina Equisetifolia*, *Sesbania Egyptia*, and various *Eucalyptus* species can deliver large net benefits even without accounting the positive environmental impact [2]. Hence if the goal of public policy is the rehabilitation of wastelands, there is little evidence to suggest biodiesel crops are the best alternative.

3. Alternative Uses of Biodiesel Plantations on Common Lands

Despite their drawbacks plantations of Jatropha, Pongamia or other similar crops on village common lands might be more desirable if the oil that is extracted is used to meet local energy needs. For example, the generation of electricity for household and commercial purposes using small and medium diesel generators fueled by vegetable oils is one such application that might provide greater local benefits compared to the utilization of such lands for supplying raw materials for markets farther away. Table 2 is a back of the envelope calculation, which estimates that amount of village common land required to produce oil for local electricity generation using diesel generators. The calculations are carried out for the case of a village with 100 households, and a supply of 100 watts of electricity for 6 hours a day per household. The amount of land required even in the low case is of the order of ten hectares. Such projects also have a higher probability of gaining acceptance within rural communities and receive greater cooperation in regeneration of wastelands.

Table 2

Back of envelope calculation of land needed to produce electricity for a village

Number of households in a village	100		
Energy supplied per household per day (Watt hours) (@ 100 watts per household for 6 hours a day)	600		
Total energy for village per year (kilo Watt hours)	21900		
Specific fuel consumption of diesel generator i.e., - straight vegetable oil consumed to produce one unit of electricity (gms per kWhr)	250		
Oil needed per year (tons per year)	5.5		
Three scenarios for oil yield	***Low***	***Medium***	***High***
Yield of oil per hectare (tons per hectare)	0.5	1	2
Land needed to produce oil (hectare)	11	5.5	2.7

Therefore given that several such alternatives exist, a holistic assessment of social, economic and environmental cost and benefits for the various possible options for wasteland development like biodiesel plantations, wood plantations, watershed development etc. should be carried out so as to maximize risk adjusted net benefits.

IV. Conclusion

We can see that the current approach, which relies mostly on one new crop that is to be cultivated under harsh environments, is not the best suited for meeting the nations biofuel goals and providing relief to the rural poor. The above analysis raises two broad sets of questions that should be addressed by policy makers before large-scale upstream and downstream investments are made towards biofuel production.

(1) If the goal is reduction of the nation's dependence on petroleum imports with the aid of biofuels what type of land resources and what type of biofuel crops should be targeted to achieve good results? Are there better alternatives to marginal lands

that would not adversely affect food production? Would focusing on private farmlands deliver higher net benefits than common property lands? Is Jatropha the best feedstock given the various uncertainties?

(2) If either regeneration of common lands or rural development is the main goal, is there evidence to suggest that single purpose crops like Jatropha are superior to other multi-purpose crops like those that would supply modern biofuels along with food and fodder and fuel wood for cooking and/or electricity production?

While energy security, reduction of harmful emissions associated with energy use, wasteland rehabilitation, rural development and poverty alleviation are all important goals there is little scientific evidence to suggest public investments in biodiesel plantations on wastelands can contribute positively to each one of those goals. In fact there is reason to believe planting of Jatropha might be detrimental to some of those goals. The reliance on just one or two crops also presents a higher risk of scarcity in biofuel supply due drought or pest attacks that might result in crop failure. This is especially important in cases where cultivation is to be undertaken on marginal lands with little or no variable inputs. Scientific research should therefore be directed towards development of a wide variety of crops and technologies that are suited to the diverse socio-economic and environmental conditions to in rural India. At the same time the efforts of scientists and extension agencies should be complimented by clear cut policies like mandated renewable fuel standards, minimum support prices for biofuel crops etc. which provide adequate incentives for industry and agriculturists to undertake the necessary investments for deployment of such technologies. Jatropha and Pongamia might have a very important role to play in meeting the nation's need for liquid fuels in the future but they also present substantial risks and challenges that need to be addressed before huge amount of time and money invested in scaling them up.

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