Manuscript Number: MS-20119

Projections and Sustainability of Biofuels in India: Lessons for Punjab[#]

Jenny Kapngaihlian[1*] and A.S. Bhullar[2]

[1]Assistant Professor, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Hyderabad, Telangana (India) and [1]Assistant Professor, Economics Program, University of Northern British Columbia, Prince George, British Columbia, Canada.

Email of the Corresponding Author: leivangjenny@gmail.com

Received: May 31, 2020 Revision Submitted: Revision Accepted:

ABSTRACT

This study analysed the potential and sustainability of biofuels blending in India. Thus, from the country's potential and perspective, it has expounded the lessons for biofuels production in Punjab. Growth analysis has been computed using Compound Annual Growth Rate obtained from 2006-2013, and projections were estimated until 2025. The actual total demand of ethanol could meet only the 5 percent of fuel ethanol blending mandate of the country; therefore, the redistribution of total ethanol for fuel and other purposes could meet the 5 percent fuel ethanol demand. Also, Punjab could contribute its allocated share of fuel ethanol demand for meeting the country's 5 percent blending target. However, the state could not meet the total ethanol demand as the total area required has been compromised. In biodiesel, 5 and 10 percent blending could effectively be achieved, taking the available area into concern. However, the present yield of biodiesel was insignificant, and the use of multiple feedstocks and Jatropha could meet only 0.01percent of the total blend rate.

Keywords: Biofuels demand, blending, diesel demand, petrol demand, projections, sugarcane, wastelands.
JEL Codes: Q16, Q47, Q48

INTRODUCTION

With the growing demands of transport fuel, a need was felt to either import the crude oil or obtained it from other sources. The oil imports of Indian are projected to rise to 6 million barrels per day by 2030, which will make it the third-largest importer of oil (International Energy Agency, 2007). Also, India's growing oil import bill was seen as one of the main drivers behind the huge trade deficit, which rose to US$ 189.8 billion, or 10.2 percent of GDP. It leads to the widening of the current account deficit to 4.2 percent of GDP in 2011-12 (Government of India, 2013). Also, global biofuels demand is projected to grow significantly up to 55 percent in the next few decades.

Similarly, biofuels production would increase arable land use by 2.5 percent (World Energy Council, 2010). Several countries are expected to follow the lead in biofuel production and policies. Nevertheless, skepticism still arises on whether biofuels as transport fuels would be beneficial in the long run.

[#]The paper is based on the Doctoral Dissertation (Agricultural Economics) entitled *An Economic Assessment of Transport Biofuels Production in India* of the first author and submitted to PAU Ludhiana, 2015.

However, there are other positive points associated with ethanol and biodiesel, in addition to their carbon emissions neutrality and its renewable substitute of fossil fuels. The physical properties allow their easy blending with gasoline or biodiesel, just with minor adjustments in the existing engine technology and infrastructure (Rajagopal, Sexton, Roland-Holst & Zilberman, 2007). The other benefits of biofuels include decentralised production possibilities, less dependency on imported oil, and positive economic impacts on rural economies (Fraiture, Giordano & Liao, 2008). As a result, biofuels production got worldwide attention. A wide range of policies and incentives have been introduced to facilitate the growth of biofuels. A considerable investment in the research and development of biofuels is notable in most the developed countries. In developing countries, production faced many challenges and drawbacks. These still remain at an early stage of development despite the allocation of a large amount of subsidies and incentives for biofuel projects (Goh & Lee, 2010). Despite the drawbacks and challenges, biofuels come into the picture as desirable alternative sources for obtaining transport fuels.

Meanwhile, India's biofuel initiative started with the National Biofuel Mission, 2003. This initiative differs from other nations' choice of raw material for biofuel production, i.e., molasses for ethanol and non-edible oil for biodiesel (Planning Commission, 2003). Again, the National Policy on Biofuels released in 2009 aims at mainstreaming biofuels by setting an indicative target of blending up to 20 percent with petrol and diesel by 2017 (Ministry of New and Renewable Energy, 2009). At present, ethanol could meet 50 percent of the 5 percent blending requirement. However, the blend rate for biodiesel accounts for 1.6 percent of the 5 percent blending target (United States Department of Agriculture, 2014). However, the efforts made by the state, the production of biofuel, has not picked up at all. Thus, this study will analyse biofuels' potential and assess the sustainability of biofuels blending in India. Therefore, from the country's potential and perspective, it will also expound the lessons for biofuels production in Punjab.

The approach of the paper features as follows: Section 2 will present the methodology. It will be followed by Results and Discussions given in section 3. Finally, section 4 will represent the Conclusions and Policy Implications.

METHODOLOGY

Sources of Data

The secondary data on petrol and diesel demand for 2006 to 2013 were taken from Indian Petroleum and Natural Gas Statistics, Government of India, Ministry of Petroleum and Natural Gas, Economic Division. Also, the corresponding data on ethanol demand, industrial uses, and potable purposes for the same period were obtained from United States Development Agency, Biofuel Annual.

Compound Annual Growth Rate

To compute the growth analysis of petrol demand, diesel demand, ethanol demand for industrial use and potable purposes, molasses use, production, and area for biofuel crops using an exponential model.

Projection of Biofuels

The fuel demand was first projected using the growth rate calculated from 2006 to 2013 to estimate the biofuel demand. The projections were estimated up to 2025. The model was given by

$Y_{t+1} = Y_t(1+r)$

Where,

Y_{t+1} = Projected Values for t+1 year

Y_t = Values of the previous year

r = growth rate

Thus, from the estimated fuel demand, the required values at 5-20 percent blending of biofuel were be generated. The analysis was achieved under the following assumptions: i) all ethanol would be obtained from sugarcane molasses, ii) the recovery of molasses from sugarcane would be 3.5 percent, iii) ethanol recovery from molasses was taken as 25 percent, iv) average yield as 68.368 tonnes/ha and v) sugarcane utilization pattern would be 60 percent for sugar and ethanol and the remaining for khandsari, jaggery, seed, feed, wastages and other uses to work out the projected values for ethanol demand. Similarly, sugarcane production and its area at 5 and 10 percent blending were calculated up to 2025. For estimating the biodiesel demand, the analysis was structured under the following assumptions: a) 80 percent of biodiesel requirement obtained from Jatropha, b) the recovery of biodiesel as 26.15 percent, c) average yield taken as 2.5 tonnes/hectares. Also, the projected Jatropha production and its area were estimated for the same period.

RESULTS AND DISCUSSION

Potential for Ethanol Production

Though the country has made a 5 percent blending mandate by 2012, Punjab has been utilizing its ethanol produced from sugarcane molasses for industrial uses and potable purposes only. Thus, transport ethanol has been more or less non-existent in the state. However, let us assume that the government of India has made a mandate for the top 15 sugarcane producing states to contribute some percentage of their ethanol produced for transport ethanol production. In 2012-13, sugarcane production in India and Punjab accounted for 341.20 and 5.92 million tonnes, respectively, with Punjab contributing to 1.74 percent of the total production.

Before undertaking the study in the state, the projected petrol demand and ethanol demand in India for various uses were estimated using the growth rate. The growth rates were analyzed from the data obtained from 2006-2013, and projections were prepared until 2025. The CAGR for petrol demand, industrial use, potable liquor, and real demand has been estimated at 9.87percent, 2.13 percent, 2.26percent, and 11.67percent, respectively. However, since the CAGR of real demand was non-significant. So, the real demand for ethanol was not estimated.

Here, Table 1 has given the perusal of projected ethanol demand for various uses in India. The estimates of petrol demand in 2017, 2020, and 2025 were 24.05, 31.90, and 51.07 metric tonnes. A study estimated the projected petrol demand to be 21.61 Mt in 2016-17, and that of the year 2020-21 was projected at 29.94 Mt (Shinoj, Raju, Chand, Kumar, & Msangi, 2011). Also, the estimate by those of PPAC has projected the petrol demand at 31.09 Mt for the year 2020-21. Therefore, the estimates of the present study were comparable with those of the estimates of other studies.

Table 1. Projected ethanol demand for various uses in India

(Million tonnes)

Year	Petrol demand	Fuel ethanol demand (Percent)			Ind. use	Potable liquor	Total ethanol demand (Percent)		
		5	10	15			5	10	15
2013	16.51	0.83	1.65	2.48	0.58	0.72	2.13	2.95	3.78
2017	24.05	1.20	2.40	3.61	0.64	0.79	2.62	3.82	5.04
2020	31.90	1.59	3.18	4.80	0.68	0.84	3.11	4.70	6.32
2025	51.07	2.55	5.09	7.70	0.75	0.94	4.24	6.78	9.39

Note: 1 tonne = 1267 litres (density of ethanol = 0.789 g/ml).

Meanwhile, it was found that the potential for fuel ethanol demand at 5, 10, and 15 percent blending would be 1.20, 2.40, and 3.61 mt, respectively, in 2017. The corresponding total ethanol demand after accounting for industrial uses and potable purposes was projected at 2.62. 3.82and 5.04 Mt, respectively, for the same year. Again, the industrial uses and potable purposes were calculated at 0.64 and 0.79 mt, respectively, for 2017. Further, the total ethanol demand at 5, 10, and 15 percent blending was projected to be 4.24, 6.78, and 9.39 mt, respectively, for 2025. The corresponding fuel ethanol demand was estimated at 2.55, 5.09, and 7.70 mt for the subsequent blending rate and same period.

Sustainability of Ethanol Production

The actual total ethanol production in 2013 accounted for 1.66 million tonnes. Since it was indicated that actual total demand could meet the 5 percent of fuel ethanol blending mandate; therefore, the redistribution of total ethanol for fuel and other purposes could meet the 5 percent fuel ethanol demand. However, the unpredictable availability of molasses has a bearing on the cost of ethanol, thereby causing disruption in the supply of ethanol for blending purposes (Shinoj, Raju,

Chand, Kumar, & Msangi, 2011). Thus, the government should consider that situation while redistributing molasses for ethanol and other purposes. Again, the fuel ethanol demand, even at 15 percent, would be 3.61 mt, and that of total ethanol would be 5.04 Mt in 2017. Thus, the government target of meeting 20 percent blending by 2016-17 (Planning Commission, 2003) has been an unrealistic assumption.

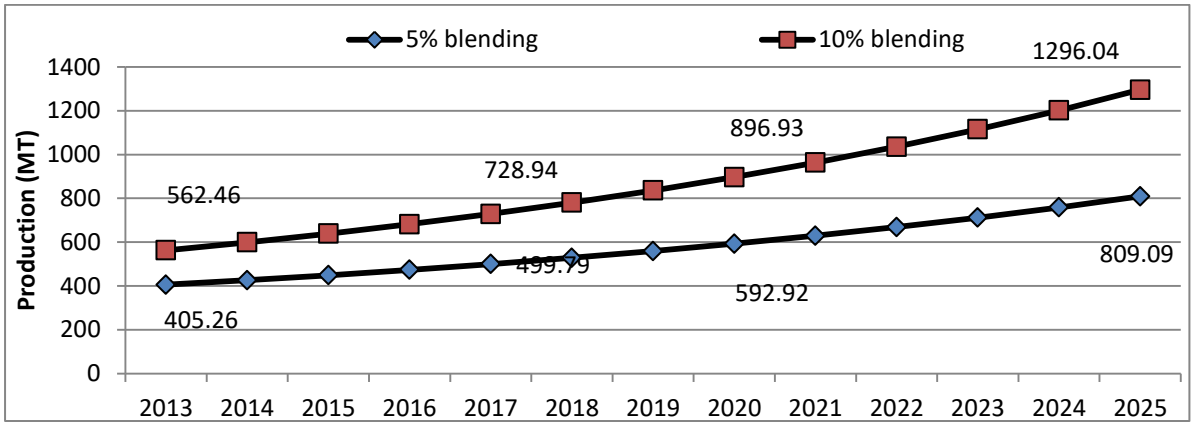

Figure 1. Projection of sugarcane production at 5 and 10 percent blending in India

Here, figure 1 has given the projected sugarcane production at present, 5 and 10 percent blending for total ethanol demand in India. The scenario analysis has advocated that the potential for sugarcane production at 5 and 10 percent blending for total ethanol, including the sugar production and associated products, would be 405.26 mt and 562.46 mt, respectively for the year 2013. Similarly, the sugarcane produced at 5 percent blending and associated during 2017, 2020, and 2025 have been estimated at 499.79, 592.92, and 809.09 mt, respectively. Likewise, for 10 percent blending and associated products, the projected sugarcane production would be 728.94, 896.93, and 1296.04 mt for the same period.

Meanwhile, the corresponding acreage of sugarcane at 5 percent and 10 percent blending for total ethanol demand have accounted for 5.93 Mha and 8.23 Mha, respectively, for the year 2013. Also, the acreage required has accounted for 7.31, 8.67, and 11.83 Mha during 2017, 2020, and 2025 respectively, at 5 percent blending, including sugar production and associated products (figure 2). However, if the government plans to introduce the 10 percent blending as indicated by National Policy on biofuels, 728.94 million tonnes of sugarcane and 10.66 Mha acreage would be required by 2017.

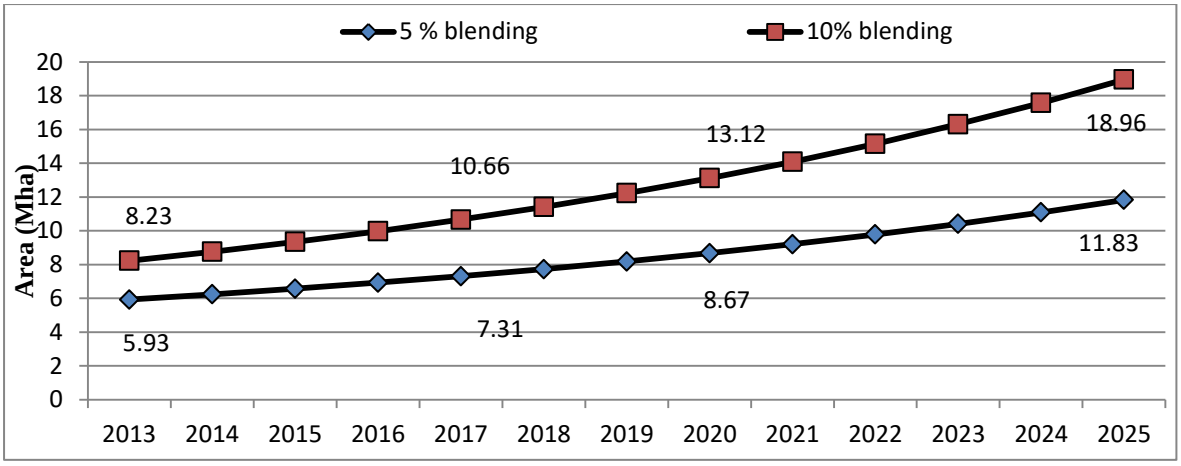

Figure 2. Projection of Acreage of sugarcane at 5 and 10 percent blending in India

The actual production and area required to meet the total ethanol demand in 2013 were 315.71 mt and 4.62 Mha. As a result, to meet the 10 percent blending target, the production and area under sugarcane need to increase more than two times the current production and acreage requirement. Therefore, the mandate of meeting 20 percent blending mandates of ethanol by the country seems to be an unrealistic assumption.

Lessons for Punjab for Ethanol Production

For this study, three year average of the share of Punjab to India's sugarcane production was taken, accounting for 1.73 percent (ISMA). Here, Table 2 gives the details of production from sugarcane in India and its potential in Punjab for the year 2013. Considering ethanol blending in India, 5 percent blending was the most realistic assumption (Table 1). Hence, the share was taken from the required potential at 5 percent blending in Indian conditions. In 2013, the area and production of sugarcane in India were 5.08 Mha and 358.35 mt. Therefore, to achieve the 5 percent blending for total ethanol demand, sugarcane area and production need to be increased by 14.33 and 11.68 percent. However, the fuel ethanol demand at 5 percent blending could be realized as the 2.31 Mha area would be utilized for sugarcane production, producing 158.10 mt.

Meanwhile, the actual fuel ethanol demand accounted for 0.36 Mt total ethanol demand at 1.66 mt in the same period. Thus, the sugarcane production at actual blending accounted for 68.57 and 316.19 mt for the fuel ethanol and total ethanol demand, and the required corresponding areas were worked out at 4.62 and 1.00 Mha for fuel ethanol and total ethanol demand.

Table 2. Details of ethanol production from sugarcane in India and its potential in Punjab, 2013

(Million tonnes: mt)

Particulars	Target (Percent)	Ethanol target equivalent blending	Total sugarcane production	Total molasses produced	Acreage required (Mha)
India					
Potential					

Total ethanol demand	5.00 (100.00)	2.13	405.72	8.52	5.93
Fuel ethanol demand	5.00 (100.00)	0.83	158.10	3.32	2.63
Actual					
Total ethanol demand	-	1.66	316.19	6.64	4.62
Fuel ethanol demand	-	0.36	68.57	1.44	1.00
Original	-	-	358.35	-	5.08
Punjab					
Total ethanol demand	0.0865 (1.73)**	0.037	7.05	0.148	0.12
Fuel ethanol demand	0.0865 (1.73)**	0.014	2.67 (47.25)	0.056 (47.05)	0.04 (44.55)
Original	-	-	5.65 (100.00)	0.119 (100.00)	0.094 (100.00)

Crops	**Water used (mm/ha)**	**Water required**	
		Fuel ethanol (million mm)	**Total ethanol (million mm)**
Sugarcane	1500-2500	66.67-111.11	176.19-293.65
Wheat	450-650	20.00-28.89	52.86-76.35
Paddy	900-2500	40.00-111.11	105.71-293.65

Punjab contributes 1.73 percent of the total sugarcane production in India (ISMA).
Figures in the parentheses indicate percentages to ratio.
Molasses recovery from sugarcane = 3.5 percent; Ethanol recovery from molasses = 25 percent. The yield of sugarcane for Punjab= 60 tonnes/hectare; Sugarcane utilization for sugar and ethanol production = 60 percent.
Water required for sugarcane = 1500-2500 mm/ha; Wheat = 450-650 mm/ha; Paddy = 900-2500 mm/ha. (Reddi and Reddy, 2012).

Though the actual total ethanol demand could meet the 5 percent blending target of fuel ethanol demand, but it could meet 77.93 percent of the potential total ethanol demand. Since Punjab ranks tenth in sugarcane production among the sugarcane producing states in India, allocating ethanol for transport ethanol has been binding in the state. Thus, the potential ethanol target equivalent blending was estimated for the state from the country's target. The yield of sugarcane in Punjab was assumed to be 60 tonnes/hectares. Thus, the ethanol target equivalent blending for Punjab was estimated at 0.037 Mt and 0.014 Mt for total and fuel ethanol demand with their associated products, respectively, for the year 2013. Also, their respective sugarcane productions were calculated at 7.05 Mt and 2.67 Mt for the same period.

Again, the required acreage at total and fuel ethanol, including the associated products, has accounted for 0.12 and 0.04 Mha for the same period as well. As a result, the state could meet the fuel ethanol demand contributing to 44.55 percent of the total sugarcane area. Further, the molasses used to meet the fuel demand and other associated uses would be accounted for 47.05 percent. Therefore, if the mandate were made effective from 2013, Punjab in this state of affairs would contribute their share of 5 percent blending mandate for fuel ethanol demand to the country's target. However, Punjab

has to increase its total available area by around 21.67 percent for meeting the total ethanol demand and other associated products.

On the other hand, sugarcane being a water-intensive crop, the sugarcane area used would have a bearing on the water table of Punjab. As a result, the water requirement for sugarcane was compared with other annual crops such as paddy and wheat in Punjab. So, the probable area required to meet the total ethanol demand and other associated uses have consumed around 179.19-293.65, 52.86-76.35, and 105.71-293.65 million metres, in the case of sugarcane, wheat, and paddy, respectively. Correspondingly, sugarcane has utilized 66.67-111.11 million mm, while wheat consumed 20.00-28.89 million mm, and that of paddy has accounted for 40.00-111.11 million mm for fuel ethanol demand and other uses. However, sugarcane has consumed the highest capacity as compared to paddy and wheat. Also, Mino (2010) has pointed out the need to increase water efficiency or reduce the water requirements for irrigated crops to minimize the negative impacts on the domestic sugar and alcohol industry. Therefore, allocating more area under sugarcane for higher blending would not be sustainable and viable under scarce agricultural land and water.

Potential for Biodiesel Production

According to National Biofuel Mission (NBM), the country has advocated using tree-bearing oil (TBO) such as Jatropha, Pongamia, Simaruba, and neem as a feedstock for biodiesel production, and Jatropha was chosen to be the most promising and sustainable feedstock. This program was adopted to achieve rural development, environmental benefits, and employment activities (Planning Commission, 2003). The country's biodiesel production has still been in the nascent stage, even a decade after its implementation. However, the workout on the projected demand of biodiesel, Jatropha production, and their corresponding area at different blending rates in India was prepared to determine the potential of biodiesel in India.

The CAGR for biodiesel demand was estimated at 8.43 percent, while jatropha production was 8.42 percent, and its corresponding area accounted for 8.45percent. The projected potential for diesel demand during 2017, 2020, and 2025 was 94.69, 120.71, and 180.92 mt, respectively (Table 3). Shinoj, Raju, Chand, Kumar, and Msangi (2011)have indicated that projected diesel demand estimates during 2016-17 and 2020-21 were 92.15 Mt and 123.06 Mt, which was more or less comparable with the present study.

Table 3. Projected demand of biodiesel and area at different blending rates in India

(Million tonnes: mt)

Year	DD	Blending (percent)							
		5		10		15		20	
		BD	JA (Mha)	BD	JA (Mha)	BD	JA (Mha)	BD	JA (Mha)
2013	68.50	3.43	4.19	6.85	8.38	10.28	12.57	13.70	16.76
2017	94.69	4.73	5.80	9.47	11.59	14.20	17.38	18.94	23.17

2020	120.71	6.04	7.40	12.07	14.77	18.11	22.16	24.14	29.52
2025	180.92	9.05	11.09	18.09	22.14	27.14	33.21	36.18	44.23

Note: Recovery of biodiesel=261.5 kg/tonne. Yield = 2.5t/hectare; 80 percent feedstock from Jatropha
DD = Diesel Demand; BD = Biodiesel Demand; JA = Jatropha Area.

Meanwhile, table 3 also projected the required biodiesel demand during 2017, 2020, and 2025 at 4.73, 6.04, and 9.05 mt, respectively, for a 5 percent blend. Likewise, the proposed area at 5 percent blending has accounted for 5.80, 7.40, and 11.09Mha, respectively, for the same period. Also, it was found that the potential for fuel biodiesel demand for subsequent blending at 10 percent, 15 percent, and 20 percent blending would be 9.47, 14.20, and 18.94 mt, respectively, in 2017. The corresponding areas were estimated at 11.59 Mha, 17.38 Mt, and 23.17 Mha for the same subsequent blending rate and period. Further, by 2025 the respective biodiesel blending would be worked at 18.09, 27.14, and 36.18 mt. Similarly, the projected areas would account for 22.14, 33.21, and 44.23 Mha at 5, 10, 15, and 20 percent, respectively.

Sustainability for Biodiesel Production

An estimated 44.23 Mha would be required under Jatropha cultivation to meet the 20 percent blending by 2025 if the same production pattern and same feedstock were employed.

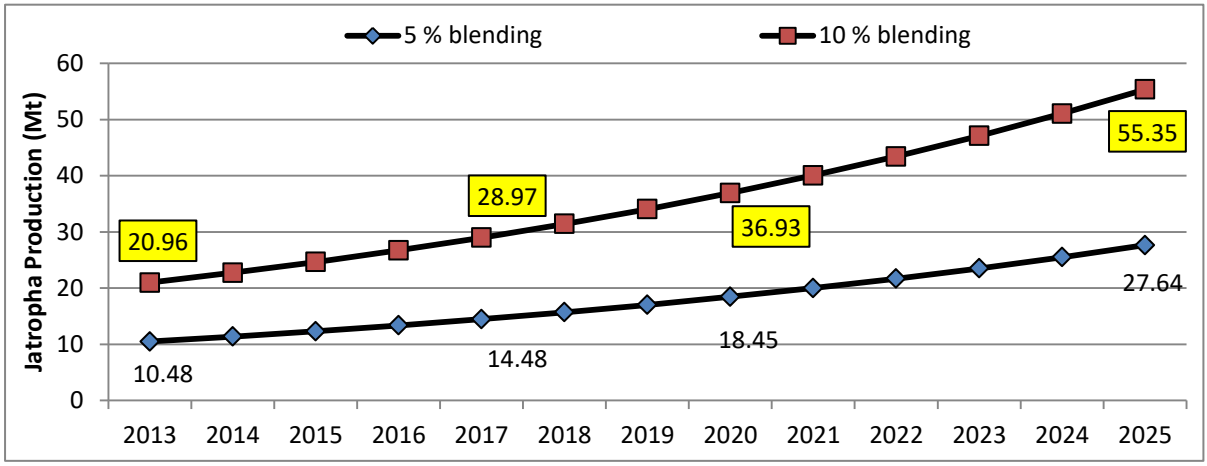

Figure 3. Projected Jatropha production at 5 and 10 percent blending in India

Also, the total area of wastelands in India, accounting for 47.23 Mha (table 4), was sufficient to meet the probable potential area. Meanwhile, figure 3 has indicated that the projected Jatropha production would be 14.48, 18.45, and 27.64 mt during 2017, 2020, and 2025 respectively, for 5 percent blending. Also, the production required for 10 percent blending was estimated at 28.97, 36.93, and 55.35 mt for the same period. Again, the projected area during 2017, 2020, and 2025 at 10 percent blending was calculated at 11.59, 14.77, and 22.14 Mha, respectively (Figure 4). Thus, the five and subsequent blending could be effectively achieved by taking the available area into concern.

Table 4. State-wise wastelands of India, 2010

(Mha)

States	Total wastelands	Percent share	Rank
Andhra Pradesh	3.88	8.21	4
Arunachal Pradesh	0.57	1.22	19
Assam	0.88	1.86	15
Bihar	0.68	1.45	17
Chhattisgarh	1.18	2.50	11
Goa	0.05	0.11	28
Gujarat	2.14	4.52	7
Haryana	0.23	0.50	24
Himachal Pradesh	2.25	4.76	6
Jammu and Kashmir	7.38	15.62	2
Jharkhand	1.17	2.47	12
Karnataka	1.44	3.06	9
Kerala	0.25	0.52	23
Madhya Pradesh	4.00	8.48	3
Maharashtra	3.83	8.10	5
Manipur	0.70	1.49	16
Meghalaya	0.39	0.82	21
Mizoram	0.60	1.27	18
Nagaland	0.48	1.02	20
Orissa	1.66	3.53	8
Punjab	0.10	0.22	27
Rajasthan	9.37	19.84	1
Sikkim	0.33	0.69	22
Tamil Nadu	0.91	1.93	14
Tripura	0.13	0.28	26
Uttar Pradesh	1.10	2.33	13
Uttarakhand	1.28	2.71	10
West Bengal	0.20	0.42	25
UTs	0.03	0.07	29
India	**47.23**	100.00	

Source: www.indiastat.com.

However, despite the availability of wastelands to meet the projected blending target, yet biodiesel production in the country has been insignificant. In 2013, biodiesel plants produced around 0.04 million tonnes of biodiesel from multiple feedstocks, estimated at 0.01 percent of the projected 5 percent blending target. As a result, the country could not even achieve 5 percent of the required blend rate, using multiple feedstocks such as used cooking oil, animal fats and tallows, and tree oils in India (United States Department of Agriculture, 2014). Thus, not only land, water (Ariza-Montobio & Lele, 2010), better agronomic approaches, government intervention in the form of appropriate pricing policies, fair taxation, subsidies, campaigns, support, and appropriate technology (Biswas, Pohit & Kumar, 2010) played an important role for biodiesel production.

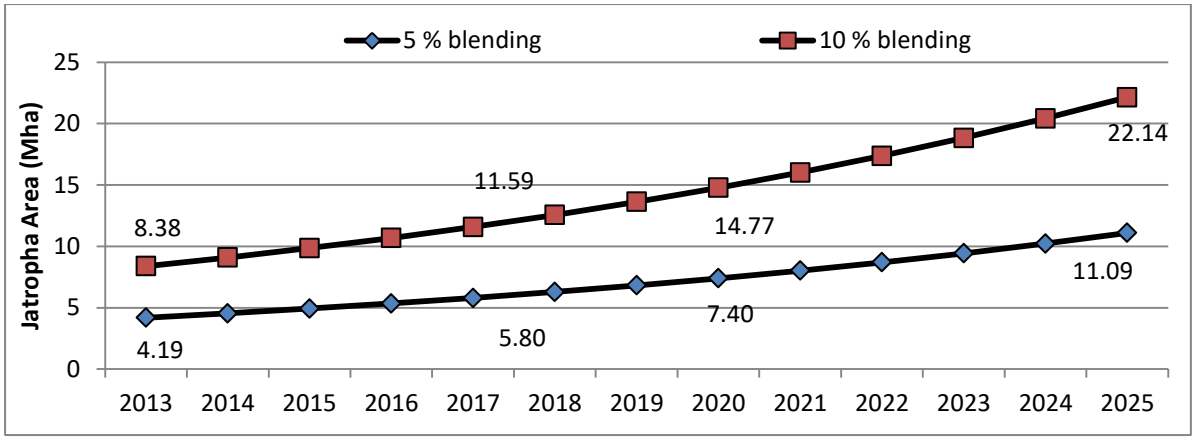

Figure 4. Projected Jatropha area at 5 and 10 percent blending in India

Besides, the intentions of the corporate and prevalence of weak laws and flawed operation of subsidies, poor follow up, and weak monitoring of the program (Goh & Lee, 2010) has hindered the growth of biofuel production. Thus, the promotion of potential synergies with respect to the reclamation of degraded lands, the creation of rural livelihoods, and the promotion of energy security were necessary for the proper implementation and success of biofuel production in India (Ravindranath, Lakshmi, Manuvie, & Balachandra, 2011).

Lessons for Punjab for Biodiesel Production

On the other hand, in Punjab, biodiesel production was done at a small scale (farmers' level) in agricultural land, and farmers used their products for their consumption. As a result, the production of biodiesel as a transport fuel was not indicated. Also, even in agricultural lands, irrigation was necessary for proper growth, high oil content, and plant yield. Again, the wastelands in Punjab ranked the third lowest, thus negligible compared to the country's available wastelands contributing to 0.22 percent of the total area (Table 4). Further, the government support alone could not be viable when most farmers growing Jatropha have switched to other profitable crops at the farmers' level.

Additionally, other studies (Ariza-Montobio & Lele, 2010; Biswas, Pohit & Kumar, 2010) too mentioned the non-viability of Jatropha in scarce land and water conditions. Therefore, it was suggested that the growing of Jatropha at a large scale in wastelands has appeared to be unviable in Punjab conditions. As a result, the potential of biodiesel would not be estimated in this state of affairs.

CONCLUSIONS

The actual total demand for ethanol could meet only the 5 percent of fuel ethanol blending mandate. In this state of affairs, Punjab would contribute only its 5percent blending mandate for fuel ethanol demand to the country's target. The projection of biodiesel demand has indicated that the 5 and 10 percent blending could be effectively achieved, taking the available area into concern. However, the present yield of biodiesel was insignificant, and even the use of multiple feedstocks along with Jatropha could meet only 0.01percent of the projected 5 percent blend rate. Hence, meeting the blending target of biofuels has become a distant reality.

It was suggested that the Government should introduce specific policies and incentives to promote biofuels. The policies should not conflict with the prevailing available resources. It could be within the grasp of the scientific technology and status quo of the state and country.

REFERENCES

Ariza-Montobbio, P., & Lele, S. (2010). Jatropha plantations for biodiesel in Tamil Nadu, India: Viability, livelihood trade-offs, and latent conflict. *Ecological Economics, 70*(20), 189-195.

Biswas P. K., Pohit, S. & Kumar, R. (2010). Biodiesel from Jatropha: Can India meet the 20% blending target? *Energy Policy, 38*(3), 1477-1484.

Fraiture de, C., Giordano, M., & Liao, Y. (2008). Biofuels and implications for agricultural water use: Blue impacts of green energy. *Water Policy, 10* **(**S1), 67–81.

Goh, C.S. & Lee, K.T. (2010). Will biofuel projects in Southeast Asia become white elephants? *Energy Policy, 38*(8), 3847–3848.

Government of India. (2013). *Indian petroleum and natural gas statistics*. Ministry of Petroleum and Natural Gas (Economic Division). New Delhi: Government of India.

International Energy Agency. (2007*). Biofuel production. IEA energy technology essentials: ETEO2*. Retrieved from http://www.iea.org/techno/essentials2.pdf.

Ministry of New and Renewable EnergyGovernment of India. (2009). *National Policy on Biofuel*. New Delhi: Ministry of New and Renewable Energy, Government of India. Retrieved from http://164.100.94.214/sites/default/files/uploads/biofuel_policy_0.pdf.

Mino, A.K. (2010). *Ethanol production from sugarcane in India: Viability, constraints, and implications* (Master thesis). University of Illinois, Urbana, Champaign. Retrieved from http://hdl.handle.net/2142/18404

Planning Commission. (2003, April 16). *Planning Commission Report of the Committee on Development of Biofuel*. Planning Commission: New Delhi: Government of India. Retrieved from https://niti.gov.in/planningcommission.gov.in/docs/reports/genrep/cmtt_bio.pdf.

Rajagopal, D., Sexton, S. E., Roland-Holst, D., & Zilberman, D. (2007). Challenges of Biofuel: Filling the tank without emptying the stomach. *Environmental Research Letters, 2*(4), 1–9.

Ravindranath, N. H., Lakshmi, C. S., Manuvie, R., & Balachandra, P. (2011). Biofuel production and implications for land use, food production, and environment in India. *Energy Policy, 39*(10), 5737-5745.

Reddi, G.H.S., & Reddy, T. Y. (2012).*Efficient use of irrigation water*, New Delhi: Kalyani New Delhi

Shinoj, P., Raju, S.S., Chand, R., Kumar, P., & Msangi, S. (2011). *Biofuel in India: Future challenges*. Policy Brief 36. National Centre for Agricultural Economics and Policy Research, New Delhi.

United States Department of Agriculture. (2014). *India biofuels annual, 2014*. GAIN Report Number 4055. USDA Foreign Agricultural Service, New Delhi.

World Energy Council. (2010). *Biofuels: Policies, standards, and technologies*. Retrieved from http://www.worldenergy.org/documents/biofuelsformatedmaster.pdf.