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Jatropha Plantation for Biodiesel Production in Rajasthan: Climate, Economics and Employment

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Abstract:

Due to rapid increase in industrialisation, exponential growth of internal combustion engines, continuous deteriorating environment have paved the way to make renewable energy resources more attractive. The most feasible way to meet this growing demand is by utilizing alternative fuels such as Jatropha which have been considered as a prospective feedstock for biodiesel production in a number of hot and humid climatic countries. It has approximately same combustion characteristics and heat value as diesel fuel and has proved better environmental friendliness as compared to diesel and gasoline. Jatropha curcas is a drought resistant perennial, growing well even in poor soil conditions. It is easy to establish, grows relatively quickly and survives, producing seeds for 50 years containing oil up to 37%. During present study, efforts have been made to study the suitability of Jatropha plantation in Rajasthan with respect to its climate suitability, financial viability and possible employment. Study is also aimed to calculate the possible replacement of diesel fuel by Jatropha seed oil if suitable waste land of 0.66 M ha in six districts of Rajasthan state which are most suitable for Jatropha plantation is used. It has been concluded that around 20.53 Lac people can be given employment for Jatropha plantation under Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) which aims at enhancing the livelihood security of people in rural areas by guaranteeing hundred days job.

Keywords: Biodiesel, Economics, Employment generation

1.0 Introduction:

India ranks sixth in the world in terms of its energy demand and its economy is growing at a rate of 8-9 percent per annum. Even today, 72% of petroleum requirement is fulfilled by oil imports. This is a matter of serious concern for the country. Therefore attempts needs to be made to reduce reliance on imports and achieve better alternative sources of energy which are suitable and sustainable for the better health of the environment (Punia M.S, 2007). As on today the total diesel fuel demand in India is 66.9 Million Metric Ton (MMT). If engine is to be operated with 20% mixing with Jatropha oil with diesel, which is most suitable replacement of diesel fuel without losing engine efficiency, the biodiesel requirement would be 13.38 MMT. For the required production, requirement of waste land would be 11.19 M ha. On an average, the consumption pattern of petroleum products in India is as shown in Table 1.

Table 1: Percent Petroleum Consumption in India in Various Sectors

Sector	Approximate Consumption
Transport (Petrol, Diesel, CNG, Aviation Fuel)	51%
Industry (Petrol, Diesel, Fuel Oil, Naphtha, Natural Gas)	14%
Commercial & Others	13%
Domestic (LPG & Kerosene)	18%
Agriculture (Diesel)	4%

Source: Kalam to Attend Jatropha Planters (2008)

The present and projected demand of diesel and biodiesel fuel according to possible substitution is indicated in Table 2. If we plan to meet out the demand of diesel only in agriculture sector by using biodiesel, the approximate requirement with different proportion of blending in diesel by bio diesel is also shown in Table-2

Table 2: Diesel Demand and Biodiesel Requirement Projections for India

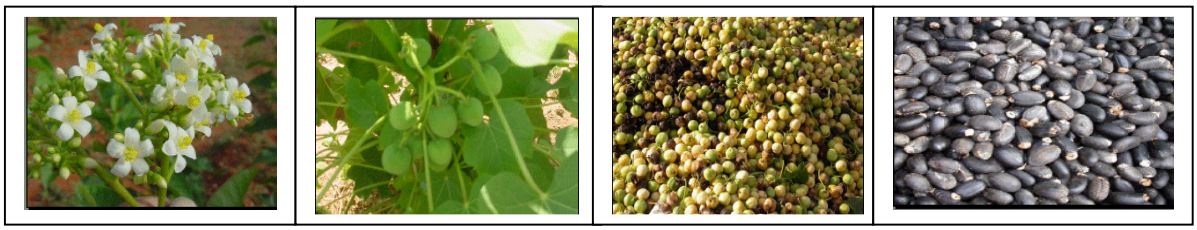
Year	2010	2020	2030
High Speed Diesel Demand (Million Tonnes)	66.07	111.92	202.84
Biodiesel At 5% Blend (Million Tonnes)	3.30	5.60	10.14
Biodiesel At 10% Blend (Million Tonnes)	6.60	11.20	20.28
Biodiesel At 20% Blend (Million Tonnes)	13.20	22.40	40.56
Demand for Agriculture Sector (@ 4%)	2.64	4.47	8.11
Biodiesel At 5% Blend (Million Tonnes)	0.13	0.22	0.40
Biodiesel At 5% Blend (Million Tonnes)	0.21	0.36	0.70
Biodiesel At 10% Blend (Million Tonnes)	0.26	0.44	0.8
Biodiesel At 20% Blend (Million Tonnes)	0.52	0.88	1.6

Source: TERI

The waste land in India is estimated at 61.2 million hectare where non edible oil crops like Jatropha can be planted. Even if the plantation is done on 10% of this land by 2016-17, Jatropha oil yield would be 11.0 million metric tons sufficient to make available to 10% blending mandate of 5.36 MT. As of now only 1% (0.62 million hectare) of the available land is being utilised for Jatropha plantations (Anand Rangachary, 2008). During its life which is of the order of 50 years, Jatropha plant requires very little water as compared to other cash crops. The oil extracted from the seeds of the Jatropha plants can be used either directly or converted into biodiesel which is very similar to conventional diesel fuel. The method used to convert these oils to biodiesel is called trans-esterification. India's total biodiesel requirement is projected to grow to 3.6 Million Metric Tons by 2011-12 (Ram Chandra, et al, 2006)

2.0 Characteristics of *Jatropha Carcas:*

It is a small flowering as shown in Fig. 1 (a) shrub with smooth gray bark, which exudes whitish, thin, latex when cut. Jatropha shrub can attain a height of up to eight to ten meters under favourable climatic conditions. In winter, the entire leaves fall and the plant is leafless.



(a) (b) (c) (d)

Fig. 1. (a) Jatropha Flowers (b) and (c) Fruits (d) Seeds

After winter is over, the fruits start producing. Depending upon the climatic conditions and availability of soil moisture, it may give several crops during the year. Fruits and seeds of the Jatropha plants are shown in Fig 1 (b), (c) and (d) respectively. Experience shows that in one hectare land, around 1600 plants in rain fed area is most favourable for appropriate development of the plant. The plantation can be done by transplanting method. About 5 kg seed is required for the plantation in 1 ha land. The plant should be preferably raised in poly bags of half kg capacity in the month of May or June. The seeds are kept in each poly bag at 6 cm depth. The eight week old seedling (6-8 inch height) used for plantation during July to September. The plant can also be raised during February March by using cuttings. During dry periods life saving irrigation or rain is essential in the State of Rajasthan. It flowers between September - December and March - April. The fruit mature 2-4 months after flowering.

2.1 Jatropha Production and Its Use:

In hot and dry conditions, around half kg of seed is obtained from each tree hence per hectare production may arrive at up to one ton. As age of the plant increases, the production also increases and may reach after eight to ten years up to 1.5 kg per plant. This level of production may be possible from a 10 year old, 5 meters tall Jatropha plant. Oil substance of Jatropha seeds varies from 30.5% to 37.5% and maximum 90% extraction hence one hectare of plantation will give 100 to 350 litres in an average soil as available in Rajasthan (Ikbal, Boora, et al, 2009). The major advantage of the permanent plantation of Jatropha is that oil yield is low in the first 2 years but stabilize after the second year. The oil can be used directly for meeting domestic needs of energy including cooking, heating and lighting in lamps. Engine operation without much change in the engine system is also possible with raw vegetable oil without much loss in engine efficiency. Leaves, residues and seed cakes can be used as bio fertiliser after suitable processing in bio gas plant and application of earth worms. This is an important source of family unit income and employment to the youths of rural areas. Even the biodiesel yield for annual harvesting may be low but significant energy is gained from the plant wood which can be used for cooking, heating and power generation.

2.2 Potential of Jatropha Plantation in Rajasthan:

Rajasthan is the second largest state of India in terms of geographical area but has only one percent of total water available in the country. Out of total available water, 83% is being utilised for irrigation purposes. Average rainfall of the state is 504 mm. Ground water is depleting rapidly and every year the level of water is going down by approximately one meter. The whole state is divided in 239 blocks out of which 191 has reached in the category of dark zone. Plantation of Jatropha may be one of the alternative solutions to conserve water with same agricultural benefits in terms of financial stability of the farmers. Per capita income of the state is only Rs. 15,000 which is just half as compared to developed states like Punjab, Haryana and Maharastra etc. Jatropha is ideally suited for cultivation in Rajasthan as it needs very little water which is scarce in Rajasthan and opens the doors for job opportunities for the youth. Rajasthan economy is mainly depended upon live stock. Among them most prominent is the Goat. Jatropha is not gazed by animals including Goat and serve as a live bio-fence around fields. Due to its toxicity, the plant also possesses medicinal properties to induce diarrhoea and regurgitation (Nepomuk Wahl, et al, 2009). Seeds may also be used for medicines, and industrial raw material for soap and cosmetics production. Jatropha seeds are very much favourable for the Germination. Udaipur is the major supplier of the Jatropha Seeds especially for the Germination.

3.0 Climate Suitability for Plantation:

Jatropha curcas is found to be in the tropics and subtropics and likes moderate heat. Only a few species is found in the semi arid land. Temperature is the main factor that affects the cultivation of Jatropha. About 95% of the Jatropha cultivation is found in the land where the annual rainfall is above 600 mm and annual temperature range of about 20 to 27 ˚C (Tarek Abdel Hamid, 2009). Rajasthan is situated between 23°3’ N and 30°12’ N latitude and 69°30’ and 78°17’ E longitude. The total land area of the state is about 3, 42,239 km^2, out of which about 1, 96,150 km^2 is arid and rest is semi-arid. The experience shows that plantation has been successful in the drier regions of the tropics with annual rainfall of 500-600 mm but for production purposes 900-1200 mm rainfall or irrigation is needed (Grass M., 2009). With less than 600 mm rainfall, it cannot grow but the places where rain fall is only 250 mm it can grow where humidity in air is very high. It cannot stand frost. It survives in a light frost but it loses all leaves. It occurs mainly at lower altitudes (0-500 m) in areas with average annual temperatures well above 20°C but can grow at higher altitudes and tolerate slight frost. Looking into these required conditions, following can be concluded with respect to Rajasthan:

1. In district like Hanumangarh, Sri Ganganagar, Bikaner, Bharatpur, Churu, Nagaur, Sikar, Barmer, Jaisalmer, Jhunjhnu, Jalore, Tonk, Swai-madhopur and Jodhpur where temperatures in winter can reach up to 1˚ C and in summer temperature becomes 48˚ C, no possibility of Jatropha plantation.
2. These districts observe series of hazy days in winter which destroys the plants and even regular irrigation cannot provide life to the plants.
3. In all these 14 districts, annual rainfall is less than 600 mm, no possibility of survival of plants.
4. Author has planted 5000 plants during rainy season at Government Engineering College Bikaner in 10 ha barren land. During summer, plant could grow up to 50 cm but during winter not a single

plant could survive. Some of the plants which have been planted in the existing zones of tall trees like Neem, the plant have survived and are at the stage of fruiting after three years.

5. The districts as per the rainfall potential for growing Jatropha are Bilwara, Banswara, Udaipur, Pali, Rajsamand, Pratapgarh and Sirohi. In the Udaipur district, Jatropha curcas is planted in agro forestry formats with food or cash crops on waste lands.

6. During rainy season, in the forest land where already various plants are surviving, Jatropha tress can be planted.

We consider only six districts of Rajasthan which are most suitable for Jatropha plantation and land with scrub and land without scrub for plantation. The total available area comes to be 0.66 M ha as shown in Fig. 2. It can be assumed here that the average production of Jatropha seed per ha is around 1000 kg having oil content of 30%. The production of oil per ha comes out to be 300 kg. The total production of oil from 0.66 Mha waste lands comes out to be 0.2 MMT of biodiesel. As per Table 1, 0.2 MMT of biodiesel production can fulfil the requirement of 8% blending of biodiesel in diesel fuel for whole country for agriculture purposes.

4.0 Economics of Jatropha Utilization:

Jatropha in Rajasthan can be planted in number of districts which have favourable climate for cultivation as shown in Fig. 2. Large chunk of unproductive land located in poverty stricken areas and in degraded forests can be used for plantation of Jatropha trees. It will also be planted on farmers' field boundaries and crop-free lands. They will also be planted in public lands such as along the railways, roads and irrigation canals.

4.1 Cost Components:

The cost components includes cost of land preparation, seeds, labour for plantation, labour for collection of seed and seed processing for extraction of vegetable oil and finally conversion into biodiesel.

4.1.1 Cost of Plantation:

The cost of plantation has been estimated to be ` 25,000 per hectare inclusive of plantation and maintenance for one year, site preparation, digging of pits, fertilizer & manure, cost of plants and planting, irrigation, de-weeding, and plant protection i.e., the stage up to which it will start seed production etc as shown in Table 4. The cost of training, awareness generation, monitoring & evaluation is also included. If we assume life of plant is around 25 years, so that cost of plantation can be equally distributed along its whole life span that comes to be ` 1000 per year for plantation and can be considered as fixed cost per year. First year onwards the expenditures are only of re plantation of some of the plants against non survivals, watering, spraying insecticides etc. which comes out to be 5000/ha. Hence the total expenditures per year will come out to be 6000/ ha adding fixed and variable expenses. Table 3 shows the comparative climate of different districts of Rajasthan and its suitability for Jatropha plantation. The total available waste land district wise taken from Wasteland atlas of India (Wasteland Atlas of India, 2003).

On 09th October 2005, on the occasion of "Inauguration of Hydrogen - CNG Mix dispenser and signing of MOU between Panchayats and M/s D1 Oil for Biodiesel" at Indian Oil ,R & D Centre Faridabad Shri Mani Shankar Ayer, Minister for Petroleum & Natural Gas and Panchayati Raj has declared the purchase price of Biodiesel as 25 per litre. For calculating the financial viability of the plantation, following assumptions have been made;

- The plant density will be 1600 per hectare.
- While under very good conditions the seed production is reported to be as high as 5 kg/tree or 8 MT per hectare and in rain fed and poor soils as low as 1.0 MT/hectare, we have assumed average conditions and soils and the production of seed as 1.5 kg per tree corresponding to 1.2 MT per hectare.
- The oil content will be 33% by weight of seed and extraction efficiency will be 90%.This works out to oil recovery of 30% implying that 3.3 kg of seed will be required for one kg of oil production. The price of oil in the year 2011 has been assumed to be 30 per /litre
- One hectare of Jatropha Plantation on an average will produce 1.5 MT of seed yielding 315 kg or 390 litre of oil.
- At the end of two years Jatropha plant will give seed to its full potential. Hence 0.66 M ha will produce 0.2 MMT ($25*10^8$ litres) of oil costing 625 crore/year and 100 crore of fertilisers, oil cake and glycerol (15 % of the total oil cost) etc. whereas expected expenditures will be only about 396 crore,

Table 3: Climatic Condition of Different Districts of Rajasthan and Available Wasteland

S. No.	District	Extreme Temperature ˚C		Average Rainfall in mm	Available Waste Land in ha	Comments
		Winter	Summer			
1	Ajmer	8	45	459	214139	Scanty rainfall, not suitable
2.	Alwar	6	46	553	335718	Suitable, can be tried for plantation
3	Banswara	6	43	909	176916	Suitable Conditions
4	Baran	10	45	812	241991	Mostly forest land, not suitable
5	Bharatpur	2	45	586	85139	Suitable, can be tried for plantation
6	Barmer	0	49	237	943108	Extreme Temperatures and Scanty rainfall, not suitable
7	Bhilwara	2	46	629	331555	Suitable Conditions
8	Bikaner	-2	49	210	603585	Extreme Temperatures and Scanty rainfall, not suitable
9	Bundi	10	45	683	208913	Mostly forest land, not suitable
10	Chittorgarh	11	44	716	187627	Suitable, can be tried for plantation
11	Churu	-2	49	319	171356	Extreme Temperatures and Scanty rainfall, not suitable
12	Dausa	3	45	590	65282	Suitable, can be tried for plantation
13.	Dholpur	7	44	625	120105	Suitable, can be tried for plantation
14	Dungarpur	10	44	686	129030	Suitable, can be tried for plantation
15	Hanumangarh	1	48	256	29931	Extreme Temperatures and Scanty rainfall, not suitable
16.	Jaipur	3	45	556	196516	Suitable, can be tried for plantation
17.	Jaisalmer	0	49	144	2918670	Extreme Temperatures and Scanty rainfall, not suitable
18	Jalore	5	45	408	169502	Land with scrub and grazing land, not suitable
19.	Jhalawar	10	45	999	267149	Shallow, deep and salinity affected land, not suitable
20	Jhunjhunu	4	48	417	67026	Extreme Temperatures and Scanty rainfall, not suitable
21	Jodhpur	3	48	292	664238	Extreme Temperatures and Scanty rainfall, not suitable
22	Karoli	7	44	635	184902	Industrial and saline wasteland, not suitable
23.	Kota	10	45	732	101077	Mostly waste land is forest or grazy, Little land is available for plantation
24	Nagaur	2	48	362	243856	Extreme Temperatures and Scanty rainfall, not suitable
25	Pali	10	41	439	250088	Suitable Conditions
26	Pratapgarh	10	44	872	120976	Suitable Conditions
27	Rajsamand	7	44	801	198694	Suitable Conditions
28.	Sawaimadhopur	3	45	701	203606	Extreme Temperatures, not suitable
29.	Sikar	1	48	409	121449	Extreme Temperatures and Scanty rainfall, not suitable
30	Sirohi	8	44	616	183076	Suitable Conditions
31	Sriganganagar	1	48	201	175262	Extreme Temperatures and Scanty rainfall, not suitable
32	Tonk	5	45	573	151533	Extreme Temperatures, not suitable
33	Udaipur	10	38	670	204548	Suitable Conditions

Table 4: Costs in Jatropha Plantation and Employment Generation per ha

S. No	Item	Cost in `		Employment in person days	
		Year		Year	
		I st	II nd	I st	II nd
1	Site preparation i.e. cleaning and levelling of field - 10 Man Days	600		10	
2	Alignment and staking, 5 Man Days	300		5	
3	Digging of pits (2500 Nos) of 30 Cm^3 size @ 30 pits per Man Day, 50 Man Days	3,000		50	
4	Cost of Manure (including transport) 2 kg. per pits during 1st year (2 MT) 1 kg. per pit during second year onwards @ `. 400/MT	2,000		20	
5	Cost of fertilizer @ `. 6 per kg (50 gm. Per plant during 1st year and 25 gm from 2nd year onward and 2 Man Days for each application.	870	495	2	1
6	Mixing of Manure, insecticides fertilizers and refilling of pits @100 pits per Man Day 25 Man Days	1,500		25	
7	Cost of plants (including carriage) 2500 Nos. during first year and 500 Nos. of plants during second year for replanting @ `. 4 per plant.	10,000	2,000	100	20
8	Planting and replanting cost 100 plants per Man Day.- 25 Man Days and 5 Man Days, respectively	1,500	300	25	5
9	Irrigation - 3 irrigation during 1st and one irrigation during 2nd year @ `. 500/- per irrigation.	1,500	500	5	2
10	Weeding and soil working 10 Man Days. x 2 times for 2 years	1,200	1,200	20	20
11	Plant protection measure	300		1	
	Sub total	22,770	4,495	263	48
	Contingency (approx. 10% of the above)	2,230	505		
	Grand Total	25,000	5,000	263	48

4.2 Employment Potential:

Sixty two percent of the total expenditure on plantation is estimated to be in the form of direct wages for unskilled labour. Employment generated will be 311 man days per hectare of plantation by the time seed production starts i.e. at the end of the second year. Seed collection is again labour intensive and after the plantation has been established it will need 40 person days of labour per hectare. As such, one hectare of plantation will create employment during the implementation of the project (first three years) of 311 person days, and of 40 man days per year on long term basis. If the Jatropha plantation in Rajasthan in the probable six districts is started at war footing, in 0.66 Mha, the man power requirement for first three years will comes out to be 20.53 lac labours assuming minimum 100 days job guarantee per year. For remaining years, the requirement will be of 3.0 lac labours assuming 40 man days per year on long term basis. Apart from generation of employment in plantation and seed collection there would be employment generation in storage of seed and oil extraction also.

5.0 Conclusions:

1. The districts as per the rainfall potential for growing Jatropha are Bilwara, Banswara, Udaipur, Pali, Rajsamand, Pratapgarh and Sirohi in Rajasthan State.
2. Above six districts of Rajasthan which are most suitable for Jatropha plantation and land with scrub and land without scrub for plantation, the total available area comes out to be 0.66 M ha
3. The total production of oil from 0.66 Mha waste land comes out to be 0.2 MMT. This much biodiesel production can fulfil the requirement of 8% blending of biodiesel in diesel fuel for whole country for agriculture purposes.
4. At the end of two years Jatropha plant will give seed to its full potential. Hence 0.66 M ha will produce 0.2 MMT (25*108 litres) of oil costing 750 crores/year (@ 30.0 / litre and 100 crores of fertilisers, oil cake and glycerine (15 % of the total oil cost) etc. whereas expected expenditures will be only about 396 crore
5. If the Jatropha plantation in Rajasthan in the probable six districts is started at war footing, in

0.66 Mha, the man power requirement for first three years will comes out to be 20.53 lac labours assuming minimum 100 days job guarantee per year.

6. For remaining years, the requirement will be of 3.0 lacs labours assuming 40 man days per year on long term basis.
7. Apart from generation of employment in plantation and seed collection, soap making etc., there would be employment generation in storage of seed and oil extraction also.

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