Policy Paper 27

Biofuels in India: Potential, Policy and Emerging Paradigms

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Foreword

Energy security has emerged as an important policy issue all over the world. Global energy markets have relied heavily on fossil fuels like coal, crude oil and natural gas, which provide almost 80 per cent of the world's supply of primary energy. Being non-renewable, they have certain limits of availability due to which they depict global destabilizing price shocks, more so in recent years. The extensive world wide use of fossil fuels has resulted in serious environmental concerns–particularly the climate change. One of the key challenges facing the developing world is how to meet its growing energy needs and sustain economic growth without contributing to climate change. An emphasis on energy security has also led to the quest for alternative sources of energy that could reduce dependence on petroleum. Amongst several alternative renewable sources of energy, biofuels have emerged as a most potent source and several countries and international institutions regard them as 'future fuels'.

India is the fifth largest primary energy consumer (as per international energy annual) and the fourth largest petroleum consumer in the world. The growing population, increasing per capita income, infrastructural development and rapid socio-economic development have spurt an increase in energy consumption across all the major sectors of the Indian economy. Given the limited domestic energy resources, escalating crude oil prices, and growth in domestic consumption of petroleum products, India's oil import bill has inflated considerably. However, biofuels sector is at its nascent stage and is evolving in India. In this context, this policy paper has addressed the evolving biofuels sector of India, and the growth of first-generation biofuels as alternatives to fossil-based transportation fuels. The paper has outlined the key issues that confront the future development of this new sector and has identified the production potential and constraints of biofuels development.

The present policy paper has discussed a number of issues related to the competitiveness of the emerging biofuels supply chain in India, and has suggested some policy reforms and interventions that are necessary for the sustainability and viability of this sector. I am sure the paper will be useful to a wider section of the society in understanding the issues related to biofuels-their potential, constraints and the emerging paradigms.

Ramesh Chand
Director

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Authors

Acronyms And Abbreviations

ABI	Agri-Business Incubator
ANGRAU	Acharya N. G. Ranga Agricultural University
APSRTC	Andhra Pradesh State Road Transport Corporation
BCR	Benefit Cost Ratio
BDBP	Biodiesel Blending Programme
CBDA	Chhattisgarh Biodiesel Development Authority
CREDA	Chhattisgarh Renewal Energy Development Authority
CRIDA	Central Research Institute for Dry Land Agriculture
CSIR	Council of Scientific and Industrial Research
CSSRI	Central Soil Salinity Research Institute
CVC	Central Vigilance Commission
CWP	Comprehensive Watershed Development Programme
DPRD	Department for Panchayati Raj and Rural Development
DRDA	District Rural Development Agency
DRDO	Defence Research and Development Organization
EBPP	Ethanol Blended Petrol Programme
EGoM	Expert Group of Ministers
FDC	Forest Development Corporation
FDI	Foreign Direct Investment
GoI	Government of India
ICRISAT	International Crop Research Institute for Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IIT	Indian Institute of Technology
IROFA	Indian Railways Organization for Alternative Fuels
IRR	Internal Rate of Return
JFMC	Joint Forest Management Committee
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MNRE	Ministry of New and Renewable Energy

MoPNG	Ministry of Petroleum and Natural Gas
MPP	Minimum Purchase Price
MSP	Minimum Support Price
NBDB	National Biofuel Development Board
NBM	National Biofuel Mission
NGO	Non-Governmental Organization
NPV	Net Present Value
NWDPRA	National Watershed Development Programme in Rain-fed Areas
OFDC	Odisha Forest Development Corporation
OMC	Oil Marketing Company
OREDA	Odisha Renewable Energy Development Agency
OUAT	Odisha University of Agriculture and Technology
RSADD	Rain Shadow Area Development Department
RSMML	Rajasthan State Mines and Minerals Ltd.
SAUs	State Agricultural Universities
SHG	Self-Help Group
SVO	Straight Vegetable Oil
TNAU	Tamil Nadu Agricultural University
TBOs	Tree-borne Oilseeds
UPSRTC	Uttar Pradesh State Road Transport Corporation

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Executive Summary

Biofuels are emerging as a renewable and eco-friendly source of energy which could help in enhancing the self-sufficiency in energy and minimizing dependence of a nation on imported fossil fuels. Towards this endeavour, the Government of India has initiated several programmes to augment production and use of biofuels during the past decades or so. The National Biofuel Mission, launched in 2003, is the frontrunner of such initiatives, with Ethanol Blended Petrol Programme (EBPP) and Biodiesel Blending Programme (BDBP) as its integral components. In these programmes, specified, time-bound targets have been laid for blending of 5 per cent, 10 per cent and 20 per cent biofuels with petrol and diesel in a phased manner so as to catalyze the transition from a completely fossil fuel based transport system to a partially biofuel-driven system. The feedstocks identified are molasses, for the production of ethanol and tree-borne non-edible oilseed crops like *jatropha* and *pongamia* for the production of biodiesel. India has some special advantages in taking up plantation of tree-borne oilseeds for the production of biodiesel as the country has vast under-utilized or unutilized land, either, fallow, barren, degraded or under-stocked, most of which are in the drought-prone areas or are otherwise unsuitable for growing of food crops. To give momentum to the biofuel sector, the Government of India has announced various support measures like *minimum purchase price* for fuel ethanol as well as biodiesel, *minimum support price* for *jatropha* seeds, etc. The 'National Policy on Biofuels', released in 2009, foresees biofuels as a potential means to stimulate rural development and generate employment opportunities, as well as aspires to reap environmental and economic benefits arising out of their large-scale use. It is categorically mentioned in the Policy that the biofuels programme is to be carried out based solely on the non-food feedstocks that are raised on the degraded or wastelands not suitable for agriculture, thus avoiding a possible conflict between food security and fuel security.

In concurrence with the larger biofuel promotion programme undertaken by the central government at the national level, various state governments are also pursuing policies and programmes in support of biofuels production and use in their respective constituencies. Some states have even drafted their own policy documents and vision statements which though distinct, are in line with the broad spirit of the National Biofuel Policy. For instance, the state of Chhattisgarh has started a comprehensive programme on *jatropha* production in wastelands and forest lands. For coordinating and monitoring various biodiesel-related activities in the state, Chattisgarh Biofuel Development Board has been created. The Board encourages the local resource-poor farmers for taking up large-scale cultivation of *jatropha* in leased-in lands with active participation of local governing bodies and NGOs. Some private entrepreneurs have also joined hands by setting up processing facilities in the *jatropha*-growing areas. Similar state organizations have been constituted in the states of Rajasthan and Uttarakhand also and various models of *jatropha* cultivation are being practised. Several central and state sponsored programmes like MGNREGS, NWDPRA, etc. are being linked to biofuel crops cultivation in various ways. The Governments of Tamil Nadu, Andhra Pradesh, Odisha and Karnataka are also encouraging cultivation of biofuel crops by framing favourable biofuel policies. Most of these states have announced *minimum support prices* for feedstock seeds, though these are not uniform across the states. Various types of tax concessions, subsidy schemes, etc. are being extended to biofuel cultivators and processing industries in these states for faster adoption of the policy prescriptions. Though, the national and state policies share a common vision, some divergences in interests are noticed with respect to specific issues. Divergence between the policies and approaches being pursued by various state governments on the matters related to tax policies, support prices, distribution of land for cultivation of biofuel crops, etc. is also visible.

Notwithstanding the various measures undertaken to provide support, progress in the biofuels sector has been rather slow in India. A major issue is that India's ethanol programme depends largely on the economic viability of 'molasses-ethanol conversion'. Recent studies have noted that the present economics of molasses-based ethanol production do not favour commercial blending of ethanol in petrol. The present study has also supported this notion and underlines that the current cost of production and pricing structure of ethanol favours its diversion towards potable purposes than for blending with petrol. Because of this reason, the oil marketing companies have so far not been able to achieve mandatory blending targets fixed by the government.

Another concern is regarding the long-term sustainability of molasses-based ethanol blending programme. The study has indicated that if the government is targeting to bring into effect 10 per cent blending by the year 2016–17, as planned in the National Biofuel Policy, production of approximately 736.5 million tonnes of sugarcane with area coverage of 10.5 million ha would be required. This means, both production and area under sugarcane will have to be more than doubled to achieve 10 per cent blending target. Given the current trends in yield and area growth, achieving the 20 per cent blending target appears still more unlikely without significant imports of ethanol. Moreover, it would be highly unsustainable to extend the sugarcane area beyond a certain limit, given the fact that sugarcane is a highly water-intensive crop with water requirement of 20,000–30,000 m^3/ha/crop. An alternative to improve the efficiency of ethanol recovery is direct conversion of sugarcane juice ethanol; but since this option would be at the cost of reduction in sugar production, and therefore is again an impracticable proposition. Thus, it is high time to think about diversifying to alternative sources of sugar and ethanol such as sweet sorghum, tropical sugarbeet, etc. which are both resource saving and sustainable.

There are various problems associated with the development of biodiesel supply chain in the country. The uncertainty regarding the transfer of ownership of community and government wastelands for cultivation of *jatropha* and other tree-borne oilseeds is another major issue that need immediate attention. Lack of good quality planting materials, low confidence among farmers to expand cultivation due to uncertainty regarding profitability, lack of an integrated approach for cultivation, etc., are hindering the expansion of area under *jatropha*. The yield potential of *jatropha* and other biofuel crops is unclear as wide variations in yield levels depending on the agro-climatic conditions, management, etc., have been noticed.

Lack of sufficient seed processing infrastructure is presently a major constraint holding back the development of biodiesel sector in India. In most of the *jatropha*- growing areas, modern processing plants have not come up in sufficient numbers so far. This is because of two major reasons: first, the government intends bringing private participation to build this capacity, but the private players visualize potential risks in investing in this area because of uncertainty regarding the supply of sufficient feedstock and market demand for biodiesel. Second, the unavailability of processing capacity is making the farmers to down-scale their production and this poses a threat to even the existing processing plants. The cost of production of biodiesel increases substantially if the units are run under low economies of scale. The problem worsens with increase in the price of seeds due to the involvement of middlemen and higher transportation costs when the seeds are sourced from distant places. A proper value chain for marketing and processing of *jatropha* seeds, distribution of biodiesel, financing services, institutional and governance arrangements is yet to be developed. Other issues like pricing and taxing of biofuels also need immediate attention for the development of the existing biofuel sector in the country.

To transfer the biofuel sector into an economically-viable venture in India, biotechnological innovations are essential. An up-to-date technology policy is central to bring in efficiency in production which is also cost-effective so that the industry would survive on its own without any subsidy or support. The focus on research has to be sustained to explore the feasibility of environment-friendly and economically-sustainable feedstocks. Improved agronomic practices for sugarcane cultivation, along with research on suitable alternatives would help provide this sector the required impetus. Research thrust to develop technologies for commercial production of second generation biofuels from cellulose-rich biomass should also go hand in hand. Efforts should also be directed towards promoting community participation and entrepreneurship through higher participation of local institutions in the process of biofuel development. Above all, it is important to ensure that the national policy on biofuels is comprehensive and is based on the pillars of economic viability, technological feasibility, environmental sustainability and market-friendliness. Such a policy should also ensure energy security without compromising with food security of the nation.

1

Introduction

1.1 Background

Before the advent of fossil fuels as a dominant source of energy in the later part of the twentieth century, energy generated from biomass (agricultural and forest products, organic wastes and residues) had a prominent position. The period that followed witnessed a role reversal with agriculture becoming increasingly reliant on fossil fuel energy for its inputs, viz. chemical fertilizers derived from fossil fuels and use of fuels to power farm machinery. Moreover, the increasing reliance on road transport system for movement of produce has made it even more dependent on fossil fuel energy. Today, any small shock in the petroleum sector, either as a cut in production or as an upward movement of prices has a direct impact on the agricultural sector. Like agriculture, many other sectors also depend on fossil fuels, which is a non-renewable source of energy. The shrinking reserves, rising demand and the resultant rise in prices of petroleum, coupled with the concerns for global climate change and energy security are forcing the world to look for its long-term alternative. It can also be viewed as a response to the global anxiety over the increasing emissions from fossil fuels, hastening the process of climate change. It is in this context that bioenergy is becoming increasingly relevant as a potential alternative to fossil fuels. Though, a number of other alternatives like ocean water power, geothermal energy, wind energy and solar energy are being explored, bioenergy is viewed as a strong source of energy in the coming years.

Bioenergy is the energy generated through biofuels that are produced from renewable sources of plant origin. For many, biofuels are still relatively unknown. Either in liquid form such as fuel ethanol or biodiesel or in gaseous form such as biogas or hydrogen, biofuels are the transportation fuels derived from the biological (agricultural) sources. The biofuels are broadly classified as first generation biofuels and second generation biofuels. First generation biofuels are sourced from the biomass consisting of sugars, starch, vegetable oils, animal starch, or other biodegradable products from agriculture, industry, forestry and households, using conventional technologies. Cereals like maize, sweet sorghum and sugar crops like sugarcane, sugar beet, etc. can be easily fermented to produce ethanol, which can be used either as a motor fuel in pure form or as a blending component in gasoline. Some oilseeds both edible (rapeseed, soybean, sunflower, oil palm) and non-edible (*Jatropha*, *pongamia,* neem, etc.) can be converted into a liquid fuel which can be blended with the conventional diesel fuel or burnt as pure biodiesel. However, the first generation biofuels have some limitations. The major one is that they cannot be produced beyond a threshold level without threatening food security. They are also not cost-competitive with the existing fossil fuels. The combating of these problems led to the search for second generation biofuels which are more sustainable, affordable and environment-friendly. These comprise ligno-cellulosic materials, including vegetative grasses, trees, waste products from crops and wood processing facilities, and municipal solid wastes; these can be converted to fuel alcohol. Recently, technologies for converting algae into ethanol have also been developed. But the process is more complex relative to the processing of sugars and grains. Techniques are being developed to convert the cellulosic crops and crop wastes to ethanol. Similarly, biodiesel produced from organic waste materials, including used cooking oils and biogas produced from animal manure and organic household wastes can be categorized under second generation biofuels. Technologies are also under development for commercial production of biofuels like biohydrogen, biomethanol, butanol and isobutanol, Fischer-Tropsch diesel, wood diesel, mixed alcohols, etc. produced from different types of biomass feedstock.

Biofuels offer a number of environmental, social and economic advantages, apart from being a renewable alternative for fossil fuels. The use of biofules may lead to reduction in vehicular pollution and emission of green house gases as it has been established that the emission of sulphur dioxide, particulate matter and carbon monoxide are less from biofuels (Subramanian e*t al.* 2005). The development of biofuels sector could result in increased cultivation of the feedstock crops like *jatropha* (*Jatropha curcas*), *pongamia (Pongamia pinnata)*, etc. especially in marginal and forest lands and could provide higher income and employment opportunities for economically and socially backward communities that cultivate these crops (UNCTAD, 2006; Rajgopal, 2008; Altenburg *et al.,* 2009). The greening of wastelands and regeneration of degraded forest lands through cultivation of biofuel crops is another added advantage (Mandal and Mithra, 2004).

On the other side, with many developed countries pursuing aggressive policies for encouraging the production and use of biofules, new dimensions on the adverse impact of expansion of biofuels have surfaced. Several studies have raised concerns over the environmental sustainability of production, overall green house gas emissions based on life-cycle analysis, and the impact on land-use and food prices (IEA, 2008; FAO, 2008). There are strong apprehensions that as more and more land is brought under biofuel crops, food prices would increase substantially affecting the poor consumers, particularly those in low-income net food importing countries. The debate on the food-fuel trade-off' is gaining momentum with most of the major biofuels-producing countries resorting to using staple food crops for bioenergy production. It is estimated that out of the total fuel ethanol being produced across the globe currently, around 60 per cent is from the cereals and the rest from sugarcane, both of which are important food crops. An estimate by the National Corn Growers Association of the United States revealed that US alone diverted around 81 million tonnes of corn in the year 2007-08 for producing fuel ethanol. This amount is evidently not small when compared with the total world trade in corn, which was of roughly 89 million tonnes in 2007-08. Similarly, Canada and China meet most of their ethanol requirements from corn and wheat. The chief feedstock for fuel ethanol in Brazil is sugarcane. In addition to cereals and sugarcane, oilseed crops like rapeseed, soybean and sunflower are also being diverted for producing biofuels. The European Union (EU) used nearly 4.7 million tonnes of rapeseed oil for biodiesel production that was around 64 per cent of their total output of rapeseed oil in the year 2007-08. In terms of area, nearly

47.8 million hectares of arable land was set apart for growing biofuel feedstock in 2006-07, which is nearly 3.4 per cent of the total arable land available for cultivation in the world (Trostle, 2008).

The diversion of food crops for energy production is believed to be one of the major contributing factors towards a drastic rise in food prices in the international market in recent period (von Braun, 2008), and especially for maize-based ethanol production in the US (Rosegrant, 2008; Runge and Senauer; 2007; 2008). In the case of rice, however, other trade policy-related factors were at work (Headey and Fan, 2010). Within a short span of time, the world witnessed unprecedented levels of food riots due to price spikes in major food grains. The price of US Hard Red Winter wheat rose to ever time high at US $ 326 /tonne, while that of US No. 2 Yellow corn went as high as US $ 223 / tonne in the year 2008. The ripples of price rise in these staples got reflected in the domestic markets of almost all the countries including India. As a result of concerns over possible impacts on food prices, China changed its domestic biofuels policy to curtail the use of food grains as feedstock crops and abruptly slowed its growth in ethanol production (Qiu et al., 2010). Rosegrant (2008) has compared the increase in prices during the period 2000-2007 with that of historic rates of growth and has come with an estimate that, around 30 per cent of increase in the weighted average of grain prices was caused by their increased demand for biofuels production. The scenario analysis based on actual plans of biofuel expansion of countries using International Food Policy Research Institute's (IFPRI) IMPACT model also cautions that the prices would further rise by 18 per cent in the case of oilseeds and by 26 per cent in corn by the year 2020.

Like many other developing countries, India also initiated its biofuel programme, primarily with a view to exploring a cleaner source of energy and to offset at least partially, the growing burden of crude oil imports. So far, the country has been largely relying on the fossil fuels-based energy, a major share of which is imported from the Middle East neighbours. However, in the recent past, the demand for this non-renewable source of energy has shot up, leading to abnormal increase in crude oil prices. It is in this context, that the Government of India initiated an ambitious programme on exploring the scope of a partial switchover to biofuels to meet the future energy needs of its citizens. Through this programme, the Government intends to address the multiple objectives of ensuring energy security with minimum damage to environment, enhancing income and employment opportunities for the rural communities as well as greening of wastelands and regeneration of degraded forest lands through cultivation of biofuel crops, particularly biodiesel crops like *jatropha* and *pongamia*. Focused efforts towards meeting these objectives were formally started in India at the dawn of the previous decade, and the launching of National Biofuel Mission (NBM) in 2003 was the frontrunner of such efforts in the country. Subsequently, the 'National Policy on Biofuels' was also released in 2009 which aims at mainstreaming the biofuels by setting an indicative target of blending up to 20 per cent with petrol and diesel in the transport sector by the year 2017 (GoI, 2009). The Biofuels Policy specifically mentions that the programme is to be carried out solely based on non-food feedstocks that are raised on degraded or wastelands not suited to agriculture, thus avoiding a possible conflict of food *versus* fuel security.

In concurrence with the official Biofuel Policy, India currently produces biofuels only from non-edible feedstocks. Molasses, a by-product of the sugar industry, is the major feedstock for bioethanol production. Limited amount of bioethanol is also produced through direct conversion of sugarcane juice and from other sources like sweet sorghum, tropical sugar beet, cassava, etc., but with no implications what so-ever on food security.

In India, biodiesel is also produced mainly from non-edible oilseed crops like *jatropha* and *pongamia*, edible oil waste and animal fats. Currently, *jatropha*, the major feedstock for biodiesel, occupies only around 0.5 million hectares of wastelands across the country, of which 65-70 per cent are new plantations of under three years. The study has shown that the farmers do not have any incentive to divert their fertile lands for *jatropha* cultivation at present. The Report of Planning Commission on Development of Biofuels (GoI, 2003) has earmarked an estimated area of 13.4 million hectares of marginal / wastelands that are suited to growing jatropha and this can cater to large-scale plantings so as to meet the blending targets fixed by the

Government of India. Similarly, the Department of Land Resources under the Ministry of Rural Development, has estimated that around 25 million hectares of fallow land is available in the country that can be diverted for growing of feedstock crops, including *jatropha*. Given these facts, there is no apprehension about a threat to food security from commercial biofuel blending programmes in India as opposed to the case with other major biofuel producing countries. However, in a scenario where the world crude oil prices reach so high that it makes the cultivation of feedstock crops more lucrative than food crops for the farmers, the diversion of fertile lands to biofuel crops and even the use of cereals and oilseeds for biofuel production cannot be totally ruled out. Therefore, it is important to visualize the implications of such situations in the future in terms of changes in land-use pattern, alterations in crop mix and subsequent impact on food production and availability so that pre-emptive/corrective policies could be planned well in advance.

Before launching National Biofuel Mission, the Government of India had undertaken a detailed *ex-ante* assessment under the aegis of the Planning Commission. It was followed by the establishment of institutional and policy framework for implementing various activities under the programme and undertaking of research and developmental activities. However, being the first of its kind, and non-existence of an enabling environment for production, processing, marketing and distribution of biofuels, the programme has witnessed a slow progress as yet. Consequently, the Government has so far not been able to meet its mandated blending targets of ethanol with petrol. Even though the Planning Commission has set a target of covering 11.2 to 13.4 M ha of land under *jatropha* cultivation by the end of 11th Five-Year Plan, the on-field experience with *jatropha* planting has been uninspiring. Similarly, the blending of diesel with biodiesel in the transport sector has not yet commenced owing to several impeding factors that pull down the development of a mature biodiesel supply chain in the country. In this context, several questions arise regarding the future of biofuel expansion in India. The important ones among them are: what is the present status of India's biofuel programme? How far the existing choice of feedstocks and technology is suitable in meeting India's biofuel production requirements in future? What are the major constraints and impediments that hold back the progress of biofuel programme in the country? What are the main pre-requisites for the development of a viable and self-sustainable biofuel industry in the country? What economic and social implications would result from large-scale expansion of biofuels and how is it going to impact the future food production systems?

In the light of the above discussion, the present study was conceived with the following specific objectives:

1. To review the present status of India's biofuel programme focusing on global, national and state scenarios biofuel policies, institutional mechanisms and infrastructural settings.
2. To assess the technical and economic potential of the major feedstocks being considered and tried for the production of biofuels in India.
3. To identify the major constraints that impede the development of biofuels in India and to suggest interventions and policy reforms to address them.
4. To assess the future needs and challenges of the biofuel sector in India and suggest proactive measures for their addressal.

1.2 Scope of the Paper

The policy paper addresses the rapidly evolving energy sector of India and the growth of first-generation biofuels as an alternative to fossil-based transportation fuels. We put the development of this sector within the context of the complex policy environment in India and illustrate the key issues that confront the future development of this sector. The paper assesses the broad ramifications of the rapid and large–scale development of biofuels in India with the objective of identifying production potential and constraints to biofuels development. It covers the range of feedstocks that are being considered currently for first-generation biofuels, and discusses their current production potential, as well as the agronomic and economic factors that enhance or limit their future growth. Besides, addressing a number of issues related to the competitiveness of the emerging biofuel supply chain, it also highlights some policy reforms and interventions that seem to be necessary to the future efficiency and continued viability of this sector.

1.3 Organization of the Paper

This Policy Paper has been organized in five chapters including the Introduction. The present status of biofuels at the global as well as country level is reviewed in chapter 2. The third chapter presents the existing policy framework on biofuels both at the national and state levels. The future potential of and challenges before the biofuel sector in India have been discussed in chapter 4. Finally, conclusions and policy implications have been presented in the last chapter.

2

Present Status of Biofuels: An Overview

2.1. Global Scenario

In the year 2009-10 the world biofuel production touched 113 billion tonnes which is 66 million tonnes oil equivalent (mtoe). Currently, around 82 per cent of the global production of liquid biofuels is in the form of ethanol. The two largest ethanol producing countries, Brazil and the USA, accounted for almost 87 per cent of the total production, the rest being contributed by China, Canada, France, India, Russia, South Africa, UK, etc. (Figure 1). The highest per hectare yield in ethanol production has been realized by Brazil which has set up an economically competitive national biofuel sector largely based on sugarcane. In Brazil, the yield of bioethanol is around 5,476 litres/ha (74.5 litres/tonne of sugarcane), which is higher than that of any other country. Brazil has developed a cost-effective technology of converting sugarcane juice directly into ethanol, in contrast to that of many other countries including India where ethanol is produced mostly from molasses a by product of sugar industry.

In comparison, the yield of maize-based ethanol in USA and China is much lower, it is around 3,751 litres / ha, and 1,995 litres /ha, respectively (Naylor *et al.,* 2007). In China, wheat, cassava and sweet sorghum are used besides corn for ethanol production. European Union (EU), another major ethanol producer, uses cereals like wheat, corn, barley and sugarbeet for production of bio-ethanol. Blending rates differ substantially across the countries. While USA mandates 3 per cent blending of ethanol with petrol, Brazil is following a very high ratio of 25 per cent blending. China and Indonesia have set a target of 10 per cent blending, whereas in EU the blending specification stands at 5.75 per cent in the year 2010 (Table 1).

Table 1: Biofuel feedstocks and blending targets in some selected countries

Country	Feedstock		Production forecast 2010 (million litres)		Blending targets (percent)	
	Ethanol	**Biodiesel**	**Ethanol**	**Biodiesel**	**Ethanol**	**Biodiesel**
USA	Corn	Soybean	46017	2707	3	1
Brazil	Sugarcane	Rapeseed, castor seed	28950	2162	25	2
EU	Wheat, corn, barley, sugar beet	Rapeseed, sunflower, soybean	6465	9888	5.75	5.75
Canada	Corn, wheat	Vegetable oils	1572	360	5	2
China	Corn, wheat, cassava, sweet sorghum	Palm oil, *jatropha*	2083	-	10	5
India	Sugarcane molasses, sweet sorghum	*Jatropha*, pongomia	1550	95	5	5
Indonesia	Sugarcane, cassava	Palm oil, *jatropha*	425	348	10	10
Malaysia	None	Palm oil	-	647	-	5

Source: F.O.Licht (2009); FAPRI (2010)

Biodiesel production that accounted for a smaller proportion of liquid biofuels, increased from 0.01 million tonnes in 1991 to 21.0 million tonnes by 2010. European Union is the major producer of biodiesel (above 47 per cent), with a significantly smaller contribution coming from the USA (13 per cent). Other major biodiesel producers include China, India, Indonesia and Malaysia (Figure 2). In EU, 80 per cent of the biodiesel is produced from rapeseed oil, the rest being animal fats and other used cooking oils. Oil palm is the major source of diesel production in Malaysia and Indonesia, whereas both USA and Brazil are using soybean to produce biodiesel (Table 1). In India, biodiesel production is only at the nascent stage, with about 95 million litres being produced from *jatropha* and *pongamia* oil.

The biofuel production programme in most of the countries is being supported through subsidies. In OECD countries, both production and consumption of biofuels are being subsidized, mainly under the banner of energy security and climate change mitigation. It is estimated that, on per litre basis, the support ranges between US $ 0.20 and US $ 1.00. Among the major producers, only the Brazilian sugarcane ethanol appears to be competitive without subsidies (FAO, 2008).

Figure 1: Ethanol production by country: 2010

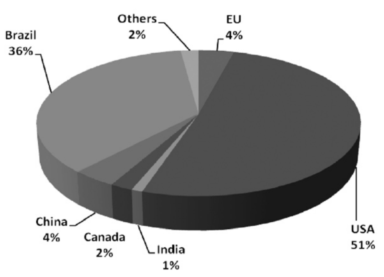
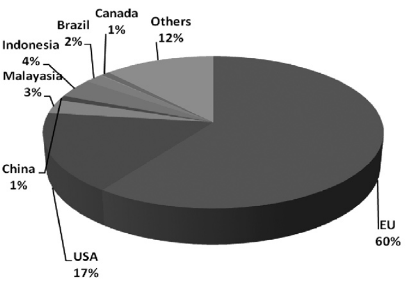


Figure 2: Biodiesel production by country: 2010



The global experience in biofuel expansion has not been very inspiring. In an urge to shift to greener sources of energy rapidly, most of the major biofuel producing countries resorted to staple food crops for production of bioenergy. Table 2 shows the extent of diversion of food grains to biofuel production by the countries like United States, European Union, Canada, China, etc. in recent years. In the year 2008, around 95 million tonnes of corn was diverted for biofuel production, which is around 12 per cent of the global corn production. Of this, United States alone used 80 per cent. Similarly, Canada and China meet most of their ethanol requirement from corn and wheat alone. More importantly, the use of cereals for biofuels production is expected to increase at the rate of 10 per cent annually during 2006-07 to 2016-17, while the cereals production itself would grow only at a rate of 1.4 per cent, indicating a squeeze in the availability of food grains for human consumption (Chand, 2009). Biodiesel is mostly produced from soybean and rapeseed & mustard which are also important food crops.

Table 2: Diversion of cereals for ethanol production: 2005-06 to 2008-09

Country	2005-06	2006-07	2007-08[1]	2008-09[2]
	Million tonnes			
USA				
(a) All	41.3	54.5	76.8	101.7
(b) Corn	40.7	53.8	76.2	100.4
(c) Sorghum	0.6	0.7	0.6	1.3
EU-27	3.2	3.4	2.9	5.2
Canada	0.7	1.5	1.8	2.5
China	9.5	11.0	11.5	12.0
Other countries	1.1	1.4	1.9	2.4
Total	55.8	71.8	94.9	123.8

1 Estimates; 2 Projections
Source : von Braun (2008)

2.2 Demand-Supply Outlook for Biofuels

Based on the mandatory blending requirements stipulated by different nations, OECD-FAO (2010) has projected the future demand for biofuels in several countries. For instance, the projected production of ethanol in China is 2083 million litres in 2010. In the case of Japan, if the country were to meet its commitment to the Kyoto Protocol, its ethanol demand will increase in a span of four years from 719 million litres in 2007 to 897 million litres in 2010 and the country will have to meet the additional demand with imports. In the European Union, approximately 15,514 million litres of biofuels are required by 2012 to meet 5.75 per cent mandatory blending target. Of this, the biodiesel demand is expected to be of 8,756 million litres. The European Union has a production capacity of 11,705 million litres of biodiesel of which its predicted production is of 9888 million litres in 2010, up by nearly 3-times from 2005. In the USA, the implementation of an updated renewable fuel standard (RFS2) is expected to substantially increase the volume of renewable fuels to be blended with gasoline from the current levels of about 3 per cent for ethanol and about one per cent for biodiesel. India, Indonesia, Canada and Malaysia are the other countries that have mandated 5 to 20 per cent blending in a phased manner over the next two to three years.

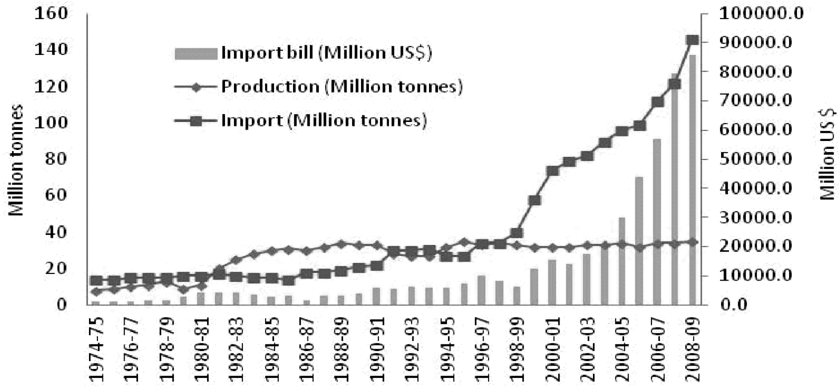
Global trade in biofuels, even though limited, is picking up gradually. Presently, trade in ethanol represents just 20 per cent of total ethanol demand, but the share has been steadily rising from about 12 per cent in 2002 (Licht, 2009). Brazilian exports of biofuels, including volume re-exported from countries in the Caribbean Basin initiative, account for about 45 per cent of their global trade. Brazil is the largest exporter of biofuels while the United States is the largest importer. The Netherlands, Germany and the United Kingdom are the largest importers in the European Union. Biodiesel derived from palm oil, exported from Indonesia and Malaysia to the European Union, accounts for the most of biodiesel trade. The United States and Brazil also export soybean biodiesel to EU countries (IEA, 2008). However, protectionist policies adopted by a number of governments to safeguard their emerging biofuel industry still act as a barrier to biofuel trade. For example, Brazilian ethanol is kept out of the USA through high tariffs and duties– although, at present, the US is a net exporter of ethanol to Brazil, and other countries, making this tariff non-binding. Furthermore, the US has dropped the tax credit (i.e. subsidy) to its domestic ethanol sector at the end of 2011, in response to political pressure towards fiscal austerity and by domestic producers of livestock who perceived the tax credit as supporting higher feed prices. Some would argue, however, that the rapid growth of the US ethanol sector in the 2005-2008 period had less to do with tax credits and subsidies and was more related to with high levels of profitability due to high oil prices (Babcock, 2011).

In nutshell, the outlook for global biofuels will depend on a number of interrelated factors, including the future price of crude oil, availability of low-cost feedstocks, and sustained commitment to supportive policies by governments, technological breakthroughs that could reduce the cost of second generation biofuels, and competitions from unconventional fossil fuel alternatives.

2.3 Indian Scenario

The domestic production of crude oil from fossil fuels has been more or less stagnant over the years and meets only 30 per cent of the national requirement, while the balance is met through imports of nearly 146 million tonnes of crude petroleum products that cost the country close to US $ 90 billion in 2008-09 (Figure 3).

Figure 3: Domestic production and import of crude oil in India: 1974-75 to 2008-09



Such high reliance on imported crude oil is impacting the country's foreign exchange reserves in a big way (Ethanol India, 2009). Over the past eight years, the consumption of motor spirit (gasoline) has increased by 6.64 per cent from 7.01 million tonnes in 2001-02 to 11.26 million tonnes in 2008-09. For high speed diesel (HSD), this growth has been 5.10 per cent from 36.55 million tonnes to 51.67 million tonnes (MoPNG, 2009). This growth is expected to continue over the next several years since it is projected that the motor vehicle population in India will grow by 10-12 per cent that would further increase the demand for petroleum products. Due to this rapid increase in demand, India's dependence on oil import is expected to rise to 92 per cent by the year of 2030 (IEA, 2009). This growing dependence on fossil fuels for powering the transport sector is the key reason for the country to embrace biofuel production on its own. In addition to, various other socio-economic and environmental concerns have also encouraged the shift.

2.3.1 Bioethanol

India is globally one of the largest producers of sugarcane and ethanol made from sugarcane molasses. For producing ethanol, India has about 330 distilleries with the annual production capacity of over 4.0 billion litres. In the year 2010, the country produced nearly 1.43 billion litres of ethanol, of which an estimated 50 million litres of ethanol were blended with petrol. Ethanol production is highly volatile in India due to the cyclical nature of sugarcane production and therefore, the blending of ethanol with petrol is also volatile. For instance, India produced around 2.15 billion litres of ethanol in 2008, of which 280 million litres were used for blended. In 2009, ethanol production went down to 1.07 billion litres and blending to 100 milion litres. Blending was further down to 50 million litres in the subsequent year. Ethanol is primarily produced by the fermentation of molasses, and it is estimated that, from one tonne of sugarcane, 85-100 kg of sugar (8.5–10 %) and 40 kg (4%) of molasses can be obtained. The recovery of ethanol from molasses is 22-25 per cent as per Indian standards. Presently, about 70-80 per cent of sugar cane produced in the country is utilized for the production of sugar and the remaining 20-30 per cent for alternative sweeteners (*jaggery* and *khandsari*) and seeds. Thus, only molasses produced during sugar production are available for ethanol production. Due to the cyclical nature of sugarcane and thus sugar production in India, sugarcane farmers and the processing industry experience periodic market gluts/deficit of sugarcane, sugar and molasses, impacting their prices and farm income. The alcohol produced in the country is used for various purposes. Around one-fourth of it is being used for industrial purposes, while 30-35 per cent is being used for potable purposes (beverages) and the rest 3-4 per cent for other uses. The surplus available alcohol is being diverted for blending with transportation fuel.

2.3.2 Biodiesel

Unlike other countries, India is not using vegetable oils derived from rapeseed & mustard, soybean or oil palm for the production of biodiesel. It is because, India is not self-sufficient in edible oils production and depends upon imports of palm oil and other vegetable oils in large quantities to meet the domestic demand. Today, around 40 per cent of the total edible oils requirement of the country is met through imports. In the year 2007-08, 23.8 million tonnes oilseeds were produced in the country that generated 8.0 million tonnes of edible oils, but the domestic consumption was as high as 11.4 million tonnes which necessitated the imports to the tune of 4.2 million tonnes. However, utilization of non-edible seed oils extracted from trees and forest sources does not interfere with food security directly if the trees are grown on marginal/waste land that does not compete with food production. Every year around 1.2 million tonnes of tree-borne non-edible seed oils are produced in the country (GoI, 2008).

In India, biodiesel is produced mostly from the non-edible oils extracted from the seeds of plants like *jatropha* and *pongamia.* Many of the strong proponents of the use of *jatropha* for producing oil-based biofuel, claim a number of potential benefits which have been widely cited in the literature (GoI, 2003; UNCTAD, 2006; ADB, 2011). These are:

- The oil produced is non-edible, which helps to avoid food-versus-fuel tradeoffs;
- It has high oil content (40 per cent) and relatively low gestation period (2-3 years);
- It can survive in areas of low rainfall and low fertility;
- It requires less inputs and minimum care for cultivation;
- The cake obtained after oil extraction can be used as organic manure, for preparation of herbal insecticides and biogas;
- *Jatropha* has the ability to assist in the build-up of soil carbon;
- *Jatropha* is an animal deterrent crop and hence not browsed by grazing animals.

The actual realization of these benefits requires a number of economic and agronomic conditions, on the ground, to be met – and remains somewhat elusive for some regions that have tried to scale up *jatropha* cultivation for large scale production. However, the current biodiesel industry in India is still at a nascent stage although the Government has ambitious plans to expand this sector.

3

Policy Framework and Enabling Factors

Food security is a national priority for India due to its one billion plus population (with about one-fourth below poverty line), rising domestic demand for food, stagnating agricultural productivity, and limited scope for expansion in area under crop cultivation. Consequently, the Government cannot afford to allow/promote the use of food feedstock for biofuel-cereal grains for ethanol production or edible oils for biodiesel production, as is being done in other biofuel producing countries. India is one of the leading importers of vegetable oils in the world as their growing demand from Indian consumers outstrips domestic production. Furthermore, growth in production of grains like wheat, corn and coarse cereals has been slow in recent years, raising concerns about their potential scarcity. High global prices of foodgrains have been a major concern for the Government, and it does not want to further aggravate the crisis by promoting the use of food commodities for biofuels production. India's biofuel policy addresses these larger concerns, and gives adequate emphasis on imparting a pro-poor dimension to the drive for harnessing the country's potential in bioenergy sector.

3.1 National Biofuel Policy of India

Government of India has undertaken several policy measures to augment production and use of biofuels during the past one decade. The launching of National Biofuel Mission (NBM) in the year 2003 under the aegis of Planning Commission, Government of India, is the frontrunner of such efforts in the country. The NBM laid special focus on phased expansion of area under biofuel feedstock crops like *jatropha*, *pongamia*, etc. It has included several micro missions covering promotion of large-scale plantation of feedstock crops in forests and wastelands, procurement of seeds and oil extraction, transesterification, blending, trade and R&D. The Ethanol Blended Petrol Programme (EBPP) and Biodiesel Blending Programme (BDBP) are the integral parts of NBM and are aimed to initiate blending of biofuels with transport fuels like petrol and high speed diesel on a commercial scale. In order to make biofuel blending a binding obligation on the states, the Ministry of Petroleum and Natural Gas (MoPNG), Government of India, in the year 2003 made 5 per cent ethanol blending in petrol mandatory across in 9 states and 5 union territories. It was implemented only partially due to the unavailability of ethanol due to low sugarcane production in 2003-04 and 2004-05. The blending mandate was further extended to cover 20 states and 8 union territories in the year 2006. This direction could also be partially implemented due to the inability of Oil Marketing Companies (OMCs)[1] to procure sufficient ethanol at the prevailing support price. Subsequently, 'The National Biofuel Policy' formulated by the Ministry of New and Renewable Energy (MNRE) was approved by the Cabinet Committee in September, 2008 and was released in December, 2009. The Policy foresees biofuels as a potential means to stimulate rural development and generate employment opportunities, as well as aspires to reap environmental and economic benefits arising out of their large-scale use. It outlines research and development, capacity building, purchase policy and registration for enabling biofuel use, including second generation[2] biofuels. The policy envisages utilization of a wide range of crops such as sugarcane, sweet sorghum, cassava, maize and tree-borne oilseeds like *jatropha* and *pongamia* for production of biofuels. It also envisages the setting up of a 'National Biofuels Development Board' (NBDB) to develop a road map for the use of biofuels in petrol and diesel engines in a time bound manner, besides taking appropriate policy measures. The national indicative target of 5 per cent blending by 2012, 10 per cent by 2017 and 20 per cent after 2017 has been recommended in the Policy. Biodiesel plantations of non-edible oilseeds on community/government/waste/degraded/marginal lands would be encouraged, while the plantation in fertile irrigated lands would not be supported. Minimum Support Price (MSP) with the provision of periodic revision for biodiesel oilseeds would be announced to provide a fair price to the growers. The details of the minimum support mechanism will be worked out subsequently and considered by the steering committee. The Minimum Purchase Price (MPP) for the purchase of bioethanol by the OMCs would be based on the actual cost of production and import price of bioethanol. In the case of biodiesel, the MPP should be linked to the prevailing retail diesel price.

[1] Presently, the state owned public sector OMCs like Indian Oil Corporation (IOC), Hindustan Petroleum (HP) and Bharat Petroleum (BP) are involved in procuring biofuels.

[2] Second generation biofuels are produced from cellulosic materials like bagasse, wood waste, agricultural and forestry residues, algae, etc.

The Policy envisages that biofuels, namely, biodiesel and bio-ethanol may be brought under the ambit of "Declared Goods" [3] by the Government to ensure unrestricted movement of biofuels within and outside the states. It is also stated in the Policy that no taxes and duties should be levied on biodiesel. Further, it is recommended to set-up an Inter-Ministerial National Biofuel Coordination Committee under the Chairmanship of the Prime Minister and a Biofuel Steering Committee under the Chairmanship of the Cabinet Secretary, Government of India, for high level coordination and policy guidance or reviewing of various aspects of biofuels development in India. The Government is considering creation of a National Biofuel Fund for providing financial incentives like subsidies and grants for new and second generation feedstocks; advanced technologies and conversion processes; and production units based on new and second generation feedstocks. Besides, the biofuel technologies and projects would be allowed 100 per cent foreign equity through automatic approval routes to attract Foreign Direct Investment (FDI), provided such biofuels produced are put only to domestic use (GoI, 2009).

3.1.1 Policy Administration

There are several ministries associated with policy making, regulation, promotion and development of the biofuels sector at the national level. The details on the responsibilities of each ministry are presented in Table 3. The Government has divided the responsibility of biofuel development among various ministries, in such a way that the roles played by each ministry are complementary to one another. By such demarcation in responsibilities, the Government intends to capitalize on the expertise of each ministry. However, convergence of the efforts needs to be ensured by effectively coordinating the activities to obtain the intended benefits.

Several programmes have been designed to encourage the planting of biofuel crops as well as for procurement of seeds and processing. For instance, the Ministry of Agriculture provides subsidy through National Oilseeds and Vegetable Oils Development (NOVOD) Board to the farmers, Non-Governmental Organizations (NGOs), individuals, etc. for the production of Tree Borne Oilseeds

[3] If given a 'declared good' status, a commodity can be transported freely across the states without attracting any border taxes.

(TBOs), including biofuel crops, under the Integrated Development of Tree Borne Oilseeds Scheme. Under this scheme, 30 per cent credit linked subsidy is provided, which is linked with 50 per cent term loan to be taken from a bank, and 20 per cent beneficiary share in the form of land, labour, etc. The Ministry of Rural Development has provided financial assistance to the tune of Rs 490 million to 9 identified states in 2005-06 and Rs 495 million to 15 states in 2006-07 for raising of *Jatropha*/*pongamia* seedlings and their plantation is done under the ongoing states/central sector area development programmes.

Table 3: Ministries involved with the development of biofuels in India

Ministry	Role
Ministry of New and Renewable Energy (MNRE)	Overall policy making, supporting research and technology development.
Ministry of Petroleum and Natural Gas (MoPNG)	Marketing, development of pricing and procurement policy.
Ministry of Agriculture (MoA)	Research and development on feedstock crops.
Ministry of Rural Development (MoRD)	Identification of wastelands; promotion of biofuel plantations.
Ministry of Science and Technology (MoS&T)	Biotechnological research on feedstock crops.
Ministry of Environment and Forests (MoEF)	Ensuring implementation of Tree-Brone Oilseeds (TBO) crop plantations in forest wastelands; and monitoring health and environmental effects of biofuels.

Source: GoI (2009)

Currently, the Government of India is in the process of firming up various policies, at the national level, which would be bindings to all the states in due course. Various steps in this direction have already been undertaken. Concurrently, some states have evolved their own biodiesel policies which are not in direct conflict with the National Biofuel Policy. The various state governments are directed to act within the broad contours and provisions of the National Biofuel Policy. The states have been given the liberty to announce their state-specific policies which are to be implemented through state agencies like panchayati raj institutes (which are village level administrative units), forest departments, universities, research institutions, etc.

3.1.2 Research and Development

Understanding research and development on biofuel crops is a major mandate of the National Biofuel Policy. It is stated in the Policy that research and development efforts would be focused on plantations, production and processing technologies of biofuels, as well as maximizing efficiencies of different end-use applications and utilization of by-products. The policy envisages to accord high priority on indigenous R&D and technology development based on the local feedstocks and needs, which would be benchmarked with international efforts. The specific areas identified in the policy framework on R&D are production and development of quality planting materials and high sugar containing varieties of sugarcane, sweet sorghum, sugar beet and cassava; advanced conversion technologies for first and second generation biofuels including conversion of ligno-cellulosic materials; technologies for end-use applications; utilization of by-products, etc.

When the NBM was launched in 2003, several above-mentioned R&D efforts were initiated along with its other mandated activities. The NOVOD Board established a "National Network on *Jatropha* and Karanja" in 2004 by involving Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAUs), Council of Scientific and Industrial Research (CSIR), Indian Council of Forestry Research and Education (ICFRE), Central Food Technological Research Institute (CFTRI), Indian Institute of Technology (IIT, Delhi) and The Energy Research Institute (TERI). Research is mainly focused on issues such as identification of elite planting material, tree improvement to develop HYVs with better quality of reliable seed source, intercropping trials, developing suitable package of practices, post-harvest tools and technology and detoxification of oil meal of important TBOs. The Central Soil Salinity Research Institute (CSSRI) under ICAR is conducting field trials on various cultivars of *jatropha* and *pongamia* for developing site-specific genotypes that can tolerate adverse climatic conditions. The Central Research Institute for Dryland Agriculture (CRIDA), another institute under ICAR, is also undertaking studies on genetic diversity, variability and other biotechnological traits on *jatropha*. The DBT has initiated a "Micro Mission on Production and Demonstration of Quality Planting Material of *Jatropha*" with the aim of selecting good germplasm and developing quality planting material. TERI has undertaken a project entitled "Biofuel Micro-Mission Network Project on *Jatropha*" with the support from Department of Biotechnology, Government of India. It aims at screening various *jatropha* collections across the country for their oil content and composition. Under another project with NOVOD, different *pongamia* collections are also being screened. While the standard seedling method of *jatropha* propagation takes two years for the plant to yield, the clonal culture raised plantations take only one year to give the first yield. In addition, TERI has developed an unconventional method where mycorrhiza application speeds up the process and the first yield arrives after seven months of planting. Field trials are being conducted in all the seven agro-climatic zones of the country. As part of its bioenergy strategy, the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) is also promoting non-edible oilseeds for the production of biodiesel. *Jatropha* and *pongamia* plantations are being introduced in watershed programmes too.

Notwithstanding these R&D efforts, there is a common perception that the large-scale *jatropha* planting exercise carried out in the country did not precede a well coordinated research programme. As a result, most of the newly raised seedlings are those of low yielding cultivars and would in turn lead to dissatisfaction among the farmers in terms of economic returns. The field studies point to the unavailability of improved varieties/cultivars as the major reason behind this trend. The fact is that, most of the R&D programmes are still at the laboratory/field trial stage and so far no improved variety of *jatropha* has been officially released by any research organization. This may have serious implications in future at the farmer level and therefore has to be accorded high priority and dedicated efforts.

3.1.3 Taxing and Pricing Policies

The National Biofuel Policy mentions that except for a concessional duty of 16 per cent on bioethanol, no other central taxes and duties are to be levied on biodiesel and bioethanol. However, the tax policies of different states towards biofuels are not uniform. The tax structure differs widely across states with the rates and forms of taxation varying from state to state. Various forms of taxes and fees include sales tax, import fee, licence fee, permit fee, excise administration fee, privilege fee, etc. The diversity in tax structure of major ethanol producing states in India is depicted in Table 4. Such diverse tax structures are perceived as a hurdle in the speedy implementation of procurement, blending, transportation and trade of biofuels. Moreover, high rates of state taxes, excise duties, and levies are rendering biofuel blending commercially unviable at many places. Efforts are being made by the MoPNG to resolve these issues and bring about uniformity in tax administration.

As per the official policy, the Minimum Support Price (MSP) of biofuels feedstock crops and Minimum Purchase Price (MPP) of biofuels are to be fixed by the Government of India with due consultations with various stakeholders. With regard to MSP, the state governments have been accorded liberty to fix the prices and undertake procurement activities of biofuels. Due to this, differential rates are in prevalence on *jatropha* and *pongamia* seeds in different states. A detailed discussion on these state pricing policies is presented in subsequent sections.

Table 4: Tax structure on ethanol in different states of India

States/UTs	Levies	Applicable rate
Uttar Pradesh	Purchase Tax	Rs 800/- per kilolitre (kL)
	Export Fee	Rs 1000/- per kL
	Import Fee	Rs 1500/- per kL
	Licence Fee	Rs 150/- per kL
	Denaturation Fee	Rs 150/- per kL
Gujarat, Daman Diu & Dadra Nagar Haveli	Sales Tax	4 %
	Import Pass	Rs 50/- per tank lorry
	Import Fee	Rs 3000/- per kL
	Licence Fee	Rs 25000/-per annum per location for 100 kL ethanol per month, Rs 0.15 million per annum per location for 500 kL ethanol per month; Rs 0.3 million per annum per location for above 500 kL ethanol per month.
Maharashtra	Sales Tax	4 %
	Export Fee	Rs 1500/- per kL
	Import Fee	Rs 1500/- per kL
	State Excise Admin. Fee	Rs 300/- per kL
	Licence Fee	Rs 25000/- per annum per location

Tamil Nadu	Sales Tax (VAT)	8 %+5 % Surcharge on sales tax
	Import Fee	Rs 1000/- per kL
	Export Fee	Rs 3000/- per kL
	State Excise Admin. Fee	Rs 1000/- per kL
	Licence Fee	Rs 25000/- per annum per location

Source: MoPNG (2009)

The central government fixed MPP of Rs 21.50/litre for ethanol in 2007, after an agreement with the sugar manufacturers and distillers. However, this purchase price became non-remunerative for the producers due to a steep rise in the price of molasses in subsequent years. This has left the producers at a precarious position, wherein they are unable to sell to the government agencies at the procurement price. Molasses being the chief feedstock for ethanol production, its price has a definite impact on the final ethanol prices. The price of molasses in turn depends on sugar production which has been fluctuating considerably over the years, leading to a large variation in ethanol production costs. The OMCs purchase ethanol from the prospective suppliers through open tender system as per Central Vigilance Commission (CVC) guidelines. When the bidders' prices are much higher than the minimum purchase price, the MoPNG is often unable to direct OMCs to stick to the predetermined price. Understanding the situation, in April, 2010, the Empowered Group of Ministers (EGoM) decided to hike the ethanol price to Rs 27 per litre. Presently, this is the prevailing price at which the OMCs to procure ethanol from the producers. The price of biodiesel remains at the level of Rs 26.50 per litre that was fixed in the year 2007and is also perceived to be below the current cost of production of biodiesel.

3.2 State-specific Policies

In concurrence with the larger biofuel promotion programme undertaken by the central government at the national level, various state governments are also pursuing policies and programmes in support of biofuels production and use in their respective constituencies. Some states have drafted their own policy documents and vision statements which though distinct are in line with the broad spirits of the National Biofuel Policy. An account of various state-specific biofuel policies is presented below and summarized in Annexure 4.

3.2.1 Rajasthan

In the state of Rajasthan, a Biofuel Authority of Rajasthan (BFA) was established and entrusted with the responsibility of promoting biofuels in the state. The state encourages the biofuels planting programme considering it as a wasteland development and agro-forestry measure which can bring about considerable greening of its wastelands with the scope of enhancing soil and water conservation and generating livelihood opportunities for marginal households. The primary focus of the state's biofuel programme is on *Jatropha curcas* with a target of covering over 21 lakh hectares of wastelands with the crop. As part of the policy, Rajasthan has adopted a multi-pronged strategy that combines the services of Self-Help Groups (SHG), community development organizations, *panchayats*, and private companies in production and marketing operations of *jatropha* seeds. Under the Rajasthan Land Revenue (Allotment of Wasteland for Biofuel Plantation and Biofuel-based Industrial Processing Unit) Rules 2007, there is a provision of leasing wastelands to private companies and government enterprises for a period up to 20 years (Ariza-Montobbio *et al.,* 2010). Based on this, the government through the intermediation of *panchayats* allots wastelands to SHGs, NGOs and private companies for *jatropha* cultivation, and provides subsidized seedlings and other inputs like fertilizers and irrigation. Under the SHGs-mediated cultivation, planting operations are mostly carried out under the centrally sponsored Mahathma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). This serves the dual purpose of employment generation and biofuel promotion. The members of the SHGs have the right to collect and sell the seeds to the government procurement agencies or to private companies. Some private companies like D1 have their presence in Rajasthan in undertaking procurement operations. The farmers are getting MSP of Rs 6/kilogram for *jatropha* seeds presently from the government seed procurement agencies, but fetch a higher price of Rs 7-10/kg if sold to the private companies, as there is high demand for seeds currently for raising nurseries. However, one major problem the state faces is the lack of adequate processing facilities that can cater to the emerging processing requirements. The local farming community feels that a visible impact on livelihood is possible only through introduction of decentralized value-addition options (CIDL, 2008).

3.2.2 Chhattisgarh

Chhattisgarh has sufficient land resources and favourable climatic conditions for the cultivation of biofuel crops like *jatropha* and *pongamia*. The biofuel programme in Chhattisgarh was launched in the year 2005 with the creation of Chhattisgarh Biofuel Development Authority (CBDA) under the aegis of Chhattisgarh Renewal Energy Development Authority (CREDA). Besides, CBDA, the department of rural development as well as forest department in the state are also active partners in its biofuel development programme. The Government of Chhattisgarh has announced several subsidy programmes and tax exemptions to promote biofuel sector in the state. These include interest subsidy, capital investment subsidy, electricity duty exemption, stamp duty exemption on land registration, etc. Further, the Government of Chhattisgarh has also issued a notification for allotting government fallow land on lease to the private investors for undertaking *jatropha/pongamia* plantation and setting up biodiesel processing facilities. Minimum support price of Rs 6.50/kg for *jatropha* seeds and of Rs 6.00/kg for *pongamia* seeds has been announced by the government to ensure fair prices for the farmers. Land leasing in the state is limited to public sector companies entering into joint venture with CBDA. The CBDA provides *jatropha* seedlings free of cost/at highly subsidized rates for planting in waste and forest lands. The authority encourages the private investors to enter into contracts with local farmers. It has established a trans-esterification plant at Raipur of the capacity of one kilo litre per day for biodiesel-production from *jatropha* seeds. Another achievement of CBDA is the establishment of biodiesel-based power generators for rural electrification in a cluster of 50 remote villages. There are also plans for setting up a state-of-the art laboratory with a capital outlay of about Rs. 1.5 crores for testing oils, biodiesel, etc. As in Rajasthan, the Department of Rural Development of Chhattisgarh state is linking the plantation activities with the ongoing MGNREGS. Several Joint Forest Management Committees (JFMCs) are also actively promoting planting of biofuel crops on forest land in the state (CBDA, 2011).

3.2.3 Uttarakhand

In Uttarakhand, *Van Panchayats*[4], JFM committees and SHGs are the grassroot level actors involved in biofuel promotion.

[4] Van Panchayats are local forest councils with rights to use forest land for development purposes.

A partnership amongst state government, Forest Development Corporation (FDC) and entrepreneurs in Uttarakhand ensures a steady supply of feedstock to the private processing plant that produces biodiesel. In this model, the FDC undertakes *jatropha* plantation in *Van Panchayat* lands with the participation of SHGs and JFMs and supplies the seeds to the biofuel processing plant run by the Uttarakhand Biofuel Limited (UBL). Under this partnership, the Uttarakhand Biofuel Board (UBB) was established as the nodal agency to coordinate various biofuel development programmes in the state. The UBB has a mandate of covering an area of 2 lakh hectares with *jatropha* by the year 2012. It has established a *jatropha* gene bank to preserve high-yielding varieties. The Board in collaboration with MNRE is also involved in biofuel-based rural electrification of remote villages in the state. The Board identifies the lands to be used for *jatropha* plantation jointly in consultation with the heads of the JFM committees. A similar mechanism is followed to identify the beneficiaries, mainly from the BPL and SC/ST families, who are given usufruct rights over 1-2 ha of plantations. The SHGs are primarily involved in producing seedlings and plantation activities. The beneficiaries are currently getting a price of Rs 3.50/kg for *jatropha* seeds under the tripartite agreement. In comparison to other states, this price is lower because of lack of competition in the state.

3.2.4 Odisha

The Odisha Biofuel Policy aims to utilize 30 per cent of the state's wastelands (0.6 million hectares) and expects to generate 10 million person-days of work through biofuel production in the state. The potential of biodiesel production has been estimated at 1000 kL per annum. The policy identifies *jatropha* and *pongamia* as the most suitable oil-bearing species which can be chosen for biofuel production. The Government of Odisha envisions setting up of a revolving fund under the stewardship of Odisha Renewable Energy Development Agency (OREDA) and Odisha Forest Development Corporation (OFDC) for giving subsidy assistance to the tune of 50 per cent to collectives like *Pani Panchayats*[5], SHGs, etc., 33 per cent to individual farmers above poverty line and 50 per cent to farmers as groups. The policy also mentions the potential inter-linkage between the biofuel programme and various development programmes and

[5] Society of farmers for locally managing small and medium irrigation systems.

institutional arrangements like Swarnajayanti Gram Swarozgar Yojana, MGNREGS, Integrated Tribal Developmental Agency, Compensatory Afforestation, Backward Regions Grant Fund, etc. will be developed Setting up of private seed collection centres and quality control centres having facilities for storage, grading, certification of seeds and quality control of oils is also envisaged. The OREDA has appointed four facilitating organizations, namely, Odisha Nature Care Council, MITS-Rayagada, Nandan Biomatrix, and Williamson Magor for assisting the District Rural Development Agency (DRDA) in identifying the potential beneficiaries for the biofuel programme. The Odisha University of Agriculture and Technology (OUAT) has been providing technical inputs to OFDC and OREDA in matters related to biofuel production and processing, besides undertaking research on biofuel crops (RCDC, 2010). Even though a biofuel policy is in place, currently the biofuel programme in Odisha is only at the inception stage.

3.2.5 Karnataka

The Government of Karnataka has identified non-edible oil bearing crops like *jatropha*, *pongamia*, *simaruba*, neem and mahua as feedstocks for biofuel production in the state. Being a sugarcane surplus state, Karnataka also plans to expand its distillation capacity for enhancing ethanol production by setting up new processing units. The State Biofuel Policy released in the year 2009, mentions that direct conversion of sugarcane to ethanol may be permitted but after fixing ceiling for sugar production. However, there is more emphasis on ethanol production from molasses so as to discourage use of irrigated lands, even indirectly for the production of fuel. The policy directs to encourage public-private partnership models through long-term lease of wastelands to the private agencies for growing biofuel feedstock crops. Traditional communities involved in oilseeds collection and oil extraction, self-help women groups and local users would be encouraged to scale-up their activities.

A 'State Task Force on Biofuel' was established in the year 2009 as an independent body to advise the government on policy and programmes related to biofuel from time to time. It is proposed to set up an apex agency by the name Karnataka State Biofuel Development Board (KSBDB) to oversee the implementation of State Biofuel Policy. As per the strategy for implementing the biofuel policy, the revenue department and forest department are to identify and declare uncultivable wastelands under both government and private ownership. The entrepreneurs would be invited to set up industrial units in the state for processing and manufacturing of biofuels within the state. Sufficient incentives like tax concessions on feedstock, machinery, products, raw materials, etc. would be extended to them in addition to other concessions already available as per the industrial policy of the state. Growers will be organized on contract farming basis and community mobilization, trading and capacity building activities will be undertaken simultaneously. The Government of Karnataka has already set up a Biofuel Park in the Hassan district and plans to establish more such parks. The insurance companies in the state are being advised to offer insurance coverage for biofuel growers as well. Several other proposals like incentives for processing units to offer remunerative prices to the farmers, incentives for transport companies to promote use of biofuels in their fleet, etc. are also in the offing (GoK, 2009).

3.2.6 Andhra Pradesh

The Government of Andhra Pradesh introduced a draft biodiesel policy in the year 2005 to facilitate investors and farmers to plant oil-bearing trees, mainly *jatropha*, *pongamia* and *simaruba*. The Policy has proposed a tripartite partnership amongst government, industry and farmers, wherein the provision of buy-back arrangements for seeds and credit disbursement for farmers routed through industry are the major highlights. There is also a proposal to constitute a Biodiesel Board, which would be an autonomous body for the promotion of cultivation of biofuel crops and biodiesel production in the state. The proposed Board will monitor the tripartite agreement signed by the stakeholders and its successful implementation. Plantations are encouraged in both private and forest lands with emphasis on contract farming arrangements between private entrepreneurs and farmers. The Andhra Pradesh Government's stint with *jatropha* in 2005 ended in a bitter note when the beneficiary farmers diverted the 90 per cent subsidy meant for *jatropha* irrigation to other crops, thereby jeopardizing the programme. Now, the state depends more on *pongamia* as a feedstock crop.

Currently, the institutional mechanism involved in the promotion of biofuels includes Rain Shadow Area Development Department (RSADD) and Department for Panchayati Raj and Rural Development (DPRD). RSADD was created in 2004 with the major objective of improvement in the livelihood of the people living in rain-deficient areas in the state; it is also involved in planning, coordination and monitoring of the biodiesel programme while DPRD is dealing with grassroot level implementation of the programme. To provide systematic research and development support, the state government has introduced a comprehensive R&D Plan for *Jatropha* involving Acharya N G Ranga Agricultural University (ANGRAU), ICRISAT, CRIDA, etc. The major activities being taken up as part of the R&D plan are germplasm collection and maintenance, molecular characterization and multiplication of elite planting materials through tissue culture, evaluation and standardization of agro-techniques, farm-trials, etc. (GoAP, 2011).

3.2.7 Tamil Nadu

As in the case of Andhra Pradesh, the initial efforts of the government of Tamil Nadu to distribute *jatropha* seedlings free of cost to farmers backfired due to lack of maintenance. Presently, the government is taking a cautious approach in promoting biofuel crops. The official Biofuel Policy of Tamil Nadu was released in the year 2007-08 with a target of promoting 100,000 ha of *jatropha* plantations over a period of five years. The State Agricultural Department in collaboration with Forest Department and Rural Development Department of the state is promoting planting of *jatropha* seedlings in wastelands. Several central and state sponsored programmes like National Watershed Development Programme for Rainfed Areas (NWDPRA), MGNREGS, Comprehensive Wastelands Development Programme (CWP), etc. are also being linked to the state's biofuel promotion activities. The Tamil Nadu Agricultural University (TNAU) is providing quality seedlings to the government and private-owned nurseries and also renders training and technical advice to the farmers and entrepreneurs.

On the financial side, Primary Agricultural Cooperative Banks in the state are extending subsidized loans to farmers involved in *jatropha* cultivation. The Industrial Policy of Tamil Nadu states that 50 per cent subsidy is applicable to planting material for *jatropha* and other biofuel crops and extends the subsidy available to the agro-processing industry to biofuel extraction plants. To incentivize the processing plants, the government has exempted purchase tax on *jatropha* seeds and VAT on *jatropha* oil for a period of 10 years from the date of commercial production. The state is actively promoting contract farming for *jatropha* cultivation. Private companies like D1 Mohan Bio Oils Ltd., AGNI NET Biofuels Pvt. Ltd., AHIMSA, etc. are offering contract farming opportunities to farmers besides extending other services like training and extension support, provision of agricultural inputs, etc. These companies are currently offering buy-back arrangements with an assured market linked price in the range of Rs 5-10 per kg for *jatropha* seeds (Ariza-Montobbio *et al.*, 2010).

3.3 A Synthesis of Biofuel Policies

India's biofuel policy has matured over the years and gives sufficient emphasis on the matters of practicality and relevance. A major highlight of the Policy is that unlike in other developed countries, it gives due consideration to the aspect of food security of the country, and promotes only non-food feedstocks for biofuel production. The Policy also exercises sufficient caution to prevent conversion of fertile lands for biofuel production. Almost all the biofuel planting programmes in the country are being undertaken only on wastelands, degraded lands or forest areas. By limiting ethanol production to molasses-based feedstock, the Policy restricts excessive dependence on sugarcane which is a highly water-intensive crop. Wherever direct conversion of sugarcane juice to ethanol is permitted, it is subject to the ceiling on sugar production. Yet, there are several sticky points over which the policy is alleged to be faltering. One major contention is that there are wide variations in price and tax policies on biofuels across states and there is a need for harmonization and rationalization of these policies. In some states, the producers find the state announced prices highly non-remunerative. Also at the central level, the support prices are not revised regularly based on the changes in cost of cultivation and fluctuations in market forces. It is suggested that biofuels may also be included in the list of crops for which the Commission for Agricultural Costs and Prices (CACP) regularly announces support prices.

According to some recent studies (Ariza-Montobbio *et al.*, 2010; Moraa *et al.,* 2009), in contrast to its presumed potential as a pro-poor means for attaining energy self-sufficiency, it is neither profitable nor pro-poor. These studies have indicated that in many parts of the country, biofuel crops are extremely low-yielding and input-intensive than was thought to be and on several occasions, are biased towards resource-rich farmers, thus reinforcing the existing trends of marginalization of small farmers. Another widespread allegation is that, in the garb of acquiring degraded land for cultivation of biofuel crops, several private companies are amassing large stretches of lands and converting them into real estates. It is also found that, in many areas, biofuel crops are turning out to be unsuitable for cultivation in relation to ecological and socio-economic conditions of the locality. Such unscrupulous plantings also lead to loss of diversity of these otherwise multi-functional lands and negate the local needs of people for fodder, fire wood, cattle grazing, etc. In this context, both national and regional policies are to be redefined and re-oriented to address the negative socio-economic consequences on impoverished farmers and should be proactively sensitive to reverse such unhealthy practices and trends.

4

Biofuels Potential and Future Challenges in India

4.1 Potential of Bioethanol Production

India is globally one of the largest producers of sugarcane and ethanol made from sugarcane molasses. Sugar industry is the second largest agricultural industry in India after cotton. Although in terms of sugarcane production, India and Brazil are almost equally placed, in Brazil, out of the total cane available for crushing, 45 per cent goes for sugar production and 55 per cent to the production of ethanol directly from the sugarcane juice. In contrast, the Indian sugar industry crushes about 70-80 per cent of the sugarcane for sugar production, with the remaining being used for local sweeteners (*khandsari* and *jaggery*), seed, feed and cane juice, chewing and wastages. Thus, only molasses produced during sugar production is available for ethanol production. Sugarcane is a crop which is subject to periodic and alternate cycles of glut and shortages with a typical 6 to 8 year cycle, wherein 3 to 4 years of higher production are followed by 2 to 3 years of lower production. The reasons for cyclical behaviour in production include factors like seasonal variations in rainfall, occurrence of extreme climatic conditions like floods, droughts, etc., variations in profitability from alternative crops, unstable pricing and taxing policies of the government, erratic release of sugarcane arrears to farmers, etc.

The area and production of sugarcane has increased drastically in the country over the past six decades. While the area increased from 1.71 M ha in 1950-51 to 4.20 M ha in 2009-10, the production also witnessed a nearby four-time increase, from 57.05 Mt to 277.7 Mt during the same period (Table 5). However, in recent years, the growth in area has been minimal with some inter-year fluctuations and yield more or less stagnant. Presently, the area under sugarcane is 2.3 per cent of total cultivable area in the country and about 5.1 per cent of the irrigated area. The sugarcane area declined from 5.15 M ha in the year 2006-07 to 4.20 M ha in 2009-10, largely due to lack of remunerative price.

Sugarcane cropping is generally considered to be resource-intensive. Only those farmers who have ready access to cash or credit, irrigation and water supply, fertilizers and pesticides undertake farming of sugarcane. The sugarcane plant requires steady irrigation for its growing period of 18 months to 2 years, so subsistence farmers are unable to farm sugarcane since sole reliance on monsoon water is inadequate. Payment for sugarcane also comes in lumps, but only after the harvest has been crushed at a sugar mill. Therefore, only those who can survive on such a system of deferred payments can afford to plant this crop. India has about 330 distilleries, with a production capacity of about 4 billion litres of rectified spirit per year, almost all of which is produced from molasses. Of this, around 120 distilleries have the capacity to distil 1.8 billion litres of conventional ethanol per year and can meet the demand of 5 per cent blending with petrol (GAIN Report, 2011).

Table 5: Area, production and yield of sugarcane in India : 1950-51 to 2009-10

Year	Area (Mha)	Production (Mt)	Yield (t/ha)
1950-51	1.71	57.05	33.42
1960-61	2.42	110.00	45.55
1970-71	2.62	126.37	48.32
1980-81	2.67	154.25	57.84
1990-91	3.69	241.05	65.40
2000-01	4.32	295.96	68.58
2006-07	5.15	355.52	69.02
2007-08	5.06	348.19	68.88
2008-09	4.40	273.93	62.32
2009-10	4.20	277.75	66.09

Source: GoI (2008; 2009)

The availability of molasses in sufficient quantities to meet the demand for ethanol depends on sugarcane production and consequently, on sugar production and government policy on use of molasses, etc. (70 % alcohol for industrial & potable purpose and 30% for fuel purpose). The lower availability of molasses and consequent higher prices of molasses could affect the production cost of ethanol, thereby causing disruptions in the supply of ethanol for the blending purpose. In the year 2010, India produced around 1435 million litres of ethanol of which 720 million litres were used for industrial purposes, 900 million litres as potable liquor and only 50 million litres were used for blending with petrol. Even though the

OMCs could blend around 200 million litres of ethanol in in the years 2006 and 2007 and 280 million litres in 2008, sharp hikes in market prices of ethanol in 2009 and 2010 resulted in a diversion of ethanol to the competing industries and thereby limiting the blending to 100 and 50 million litres in the respective years (Table 6). At the current allocation rate, ethanol production capacity is sufficient to meet the estimated ethanol demand for the 5 per cent blending with gasoline; however, it should be noted that, even this would prove inadequate to implement the 10 per cent and 20 per cent blending targets in the near future. A detailed perusal on this argument is provided in the forthcoming sections.

Table 6: Year-wise balancesheet of ethanol in India: 2006-2010
(in million litres)

Particulars	2006	2007	2008	2009	2010
Opening stock	483	747	1396	1673	1283
Production	1898	2398	2150	1073	1435
Imports	29	15	70	320	150
Total supply	2410	3160	3616	3066	2868
Exports	24	14	3	3	3
Industrial use	619	650	700	700	720
Potable liquor	745	800	850	880	900
Blending of petrol	200	200	280	100	50
Other uses	75	100	110	110	110
Total consumption	1639	1750	1940	1780	1780
Closing stock	747	1396	1673	1283	1085

Source: GAIN Report (2011)

With rising per capita income, urbanization, infrastructural development and the resultant increase in vehicular density, the demand for petrol in India is galloping ahead – the rate of growth in demand has been 8.5 per cent for petrol during the five-year period ending 2008-09. Such growth is expected to continue uninterrupted over the next several years. Taking cognizance of the government plan to implement 20 per cent blending of petrol with bioethanol by 2017, the demand for ethanol as fuel and for other alternative uses[6] was projected using the growth rate for the period 2004-05 to 2008-09 (Table 7). It was found that the fuel ethanol demand during 2011-12 for 5 per cent, 10 per cent and 20 per cent blending would be 0.72 Mt, 1.44 Mt and 2.87 Mt, respectively (925 million

[6] Annual growth rates of 3.0 per cent for industrial use and 3.3 per cent for potable use were used for the projections.

litres, 1840 million litres and 3680 million litres, respectively)[7]. The corresponding total ethanol demand after accounting for potable, industrial and other uses would be 2.08 Mt, 2.80 Mt and 4.23 Mt, respectively. In the year 2016-17, when blending at 20 per cent is to be commenced, the total ethanol requirement would be 5.92 Mt, which is equivalent to 6704 million litres[8].

Table 7: Projected ethanol demand for various uses in India

(million tonnes)

Year	Petrol demand	Fuel ethanol demand			Potable ethanol demand	Industrial and other uses ethanol demand	Total ethanol demand		
		5 per cent	10 per cent	20 per cent			5 per cent	10 per cent	20per cent
2008-09	11.25	0.56	1.13	2.25	0.65	0.60	1.81	2.38	3.50
2011-12	14.37	0.72	1.44	2.87	0.71	0.65	2.08	2.80	4.23
2016-17	21.61	1.08	2.16	4.32	0.84	0.76	2.68	3.76	5.92
2020-21	29.94	1.50	2.99	5.99	0.96	0.85	3.31	4.80	7.80

Source : Shinoj *et al.* (2011a)

4.2 Challenges before India's Bioethanol Programme

4.2.1 Economic Viability

India's bio-ethanol programme depends to a large extent on the economic viability of molasses-ethanol conversion. The supply of molasses in turn depends on the sugarcane production in the country. The spells of shortage in sugarcane production lead to reduced availability of molasses, leading to a steep rise in its prices. The inadequacy of molasses also forces most of the distilleries to utilize less than their actual plant capacity. The prices of molasses have fluctuated substantially and ranged between Rs 1,000 and Rs 5,000 per tonne during the previous decade. The ex-factory prices of molasses generally remained at around Rs 1,000/ tonne during the period 1998-2003. However, since the second half of 2003-04, molasses prices witnessed an upward movement and reached Rs 3,500/ tonne in 2004-05, before correcting to Rs 2,000-2,500 range in 2005-06 and remained in this range thereafter (ICRA, 2006). However, the drought during 2008-09 resulted in a substantial reduction in sugarcane

[7] Our estimates for petrol demand were found comparable with those of Petroleum Planning and Analysis Cell (PPAC), Ministry of Petroleum and Natural Gases, GoI (Latest PPAC estimate of petrol demand for 2020-21 is 25.4 Mt).

[8] 1 tonne of ethanol is equivalent to 1267 litres (density of ethanol is 0.789 g/mL)

production and a resultant shooting up of molasses prices to the level Rs 5,000/ tonne. This had a serious bearing on the viability of molasses-based ethanol production. The cost of production of ethanol as per the report of the Planning Commission (GoI 2003), was Rs 9.74/litre, assuming the molasses price at Rs 1000/tonne. Based on this, the Government of India fixed the minimum purchase price of Rs 21.50/litre for ethanol in 2006 (MoNRE, 2009), the price at which the sugar industry also agreed then to sell to OMCs. However, cost of production exceeded the minimum purchase price when the molasses price shot up to Rs 5,000/ tonne and even higher during 2008-09. NCAP survey[9] conducted at 3 distilleries in Uttar Pradesh in the year 2010 suggested that the average cost of production of ethanol ranged between Rs 24.10 and Rs 30.61 per litre in case of stand alone distilleries and Rs 19.62 to 26.13 per litre in case of distilleries integrated with sugar production (Table 8). The costs were estimated under two scenarios of molasses prices, viz. Rs 3500/tonne and Rs 5000/tonne.

Table 8: Cost of ethanol production from molasses in Uttar Pradesh, India: 2010

Inputs	Stand alone distillery (Rs/ litre)	Distillery integrated with sugar production (Rs/litre)
Cost on steam	0.35	0.00
Cost on power	1.30	0.00
Cost on chemicals	0.20	0.20
Cost on labour	0.10	0.06
Cost on repair and maintenance	0.18	0.18
Total variable cost excluding molasses	2.13	0.44
Interest on fixed capital	2.19	2.19
Depreciation on machinery and fixed assets	1.83	1.83
Total fixed cost	4.02	4.02
Cost of molasses (@Rs 3500 / tonne)	15.22	15.22
Cost of molasses (@Rs 5000 / tonne)	21.73	21.73
Transportation cost	2.83	0.00
Total cost of ethanol production	24.10-30.61	19.62-26.13

Note: Recovery of ethanol was assumed to be 230 litres/tonne of molasses
Source: NCAP Field Survey, 2010

[9] The questionnaire used for the survey is presented in Annexure 1.

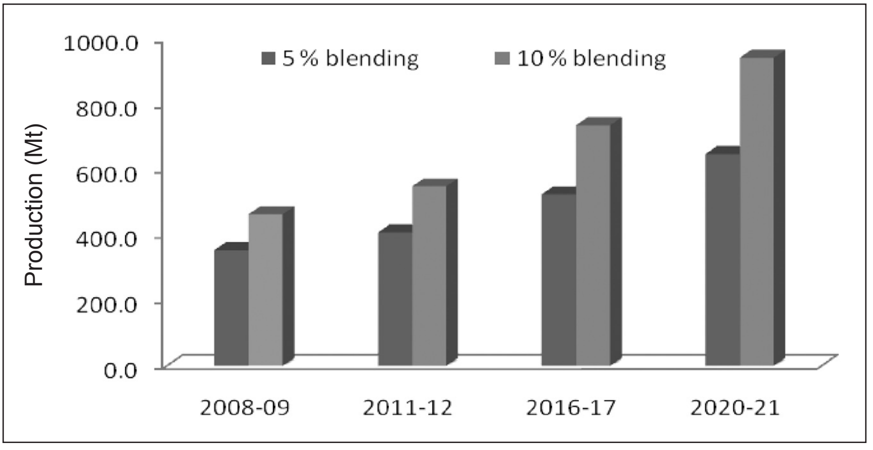
Such fluctuations are expected to continue in future also and therefore high levels of instability in prices of both ethanol and petrol deter the OMCs to strike long-term contracts with the distilleries. On the contrary, the ethanol distillers get a better price and assured demand from the beverage and pharmaceutical industries which prompt them to show more affinity to these industries rather than to OMCs. The experience indicates that OMCs so far have not been able to procure sufficient ethanol at the prevailing market rates to effect mandatory blending of 5 per cent. Even though the government revised the purchase price to Rs 27/litre in April 2010, the ethanol blending still remains much below the targeted levels.

4.2.2. Sustainability

There are arguments in favour of bioethanol that it would become economical in a scenario of higher crude oil prices, like the recent (July 2008) hike to the tune of US $ 147/ barrel. However, even in such a scenario, it would be difficult to meet the mandated ethanol blending requirement. As per the ethanol demand projections presented in Table 6, the base year (2008–09) demand for 5 per cent blending was worked out to be 0.56 million tonnes of ethanol, whereas the actual blending of fuel ethanol in 2009 was only 0.08 million tonnes (100 million litres). Even though, the total supply of ethanol (2.40 million tonnes in 2009) was sufficient to meet the total amount demanded (1.80 million tonnes), the utilization was more towards potable and industrial uses. Further, the projections show that the demand for total ethanol would reach around 2.05 million tonnes by 2011–12 and to around 2.55 million tonnes by 2016–17. As per the actual target of the government to effect 10 per cent blending by 2016–17, the fuel ethanol demand would be 1.93 million tonnes and total demand would be as high as 3.52 million tonnes.

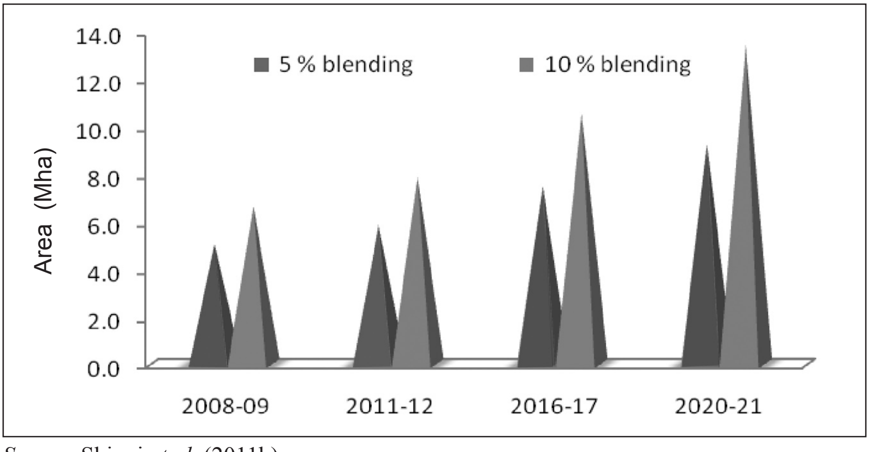
For a deeper understanding on how the ethanol blending demand would translate into future requirement of sugarcane area and production, an exercise was undertaken to work out the needed sugarcane area and production for meeting various demands of ethanol for three periods, viz. 2008–09 through 2011–12, 2016–17 and 2020-21. The fuel ethanol demands were worked out for both 5 per cent and 10 per cent blendings and the corresponding estimates of area and production are given separately. The analysis was carried out under the following assumptions: (i) all the ethanol would be produced from molasses, (ii) recovery of molasses from sugarcane would be 4 per cent, (iii) recovery of ethanol from molasses: would be 25 per cent, (iv) molasses utilization pattern would be 85 per cent for ethanol production and rest for other uses, (v) average yield of sugarcane would be 70 tonnes/ha, and (vi) sugarcane utilization pattern would be 60 per cent for sugar and ethanol production and rest for *khandsari*, *jaggeri*, seed, feed, wastages and other uses.

Figure 4: Projected sugarcane production requirement for meeting ethanol blending targets



Source: Shinoj et al. (2011b)

Figure 5: Projected sugarcane area requirement for meeting ethanol blending targets



Source: Shinoj *et al.* (2011b)

The scenario analysis has suggested that around 408.4 million tonnes, 524.6 million tonnes and 648.4 million tonnes of sugarcane would have to be produced during 2011–12, 2016–17 and 2020–21, respectively to meet the combined demand for 5 per cent blending, potable and industrial uses, and production of sugar and associated products (Figure 4). The corresponding sugarcane area required would be 5.8 M ha, 7.5 M ha and 9.3 M ha, respectively (Figure 5). However, if the government is targeting to effect 10 per cent blending by the year 2016–17 as planned in the National Biofuel Policy, production of about 736.5 million tonnes of sugarcane and area coverage of 10.5 M ha would be required (around 20–23 % in excess of that required for meeting the corresponding sugar demand). This means both production and area under sugarcane need to be more than doubled to achieve the target of 10 per cent blending. At 20 per cent blending, these estimates would be staggering and unrealistic and hence were not attempted.

An alternative to improve the efficiency of ethanol recovery is converting sugarcane juice directly to ethanol, a method which is much more efficient than ethanol production from molasses. However, presently, the country lacks both technology and infrastructure required to implement it. Another major hurdle is that diversion of sugarcane for direct ethanol production would be at the cost of reduction in sugar production. The demand for sugar is increasing at an average annual rate of 4.2 per cent for the past ten years. The current demand for sugar in the country is of 23.3 million tonnes, highest in the world. However, it is highly unsustainable to extend the sugarcane area beyond a limit, given the fact that sugarcane is a crop that is highly water-intensive with water requirement of 20,000–30,000 m^3/ha/crop. Therefore, it is high time to think about alternative sources of sugar and ethanol, which are both resource saving and sustainable.

4.3. Managing the Challenges: Need to Explore Alternative Feedstocks

The concerns regarding the feedstock availability, economic viability and sustainability of molasses-based ethanol have necessitated the search for alternative feedstocks to produce ethanol. Sweet sorghum has been found to be one such potential source of raw material for commercial ethanol production due to various advantages. Sweet sorghum is similar to grain sorghum, has rapid growth, wider adaptability and high biomass producing ability with sugar-rich stalks, and is suitable for seed propagation and mechanized crop production (Reddy *et al*., 2005). The presence of reducing sugars in this crop prevents crystallization and results in high fermentation efficiency of around 90 per cent (Ratnavathy *et* *al.,* 2004). The growing period (four months) and water requirement (8000 m^3/ha over two crops) of sweet sorghum is only one-fourth of that of sugarcane (Table 8). Moreover, the ethanol yield from two crops of sweet sorghum per year[10] is higher than that obtained from molasses in a year (700–800 litres/ ha).

At the present rates of feedstock, the per litre cost of production of sweet sorghum-based ethanol (Rs 17–19) is considerably lower than that of molasses-based ethanol (Rs 24–32). The pro-poor dimension and commercial feasibility of sweet sorghum-based ethanol production has already been demonstrated by the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) through its BioPower and Agri-Business Incubator (ABI) Initiatives. However, the potential of sweet sorghum does not seem to have been visualized by the policy makers. Adequate extension efforts, coupled with repeated field trials and industrial trials all over the country are required to sensitize the farmers and distillers to enable large-scale adoption of sorghum (Dayakar Rao *et al*., 2004). Tropical sugar beet is another potential feedstock for ethanol production, even though the scope of its commercial exploitation has not so far been widely tested in India.

Table 9: A comparison of cost of ethanol production from sugarcane, sweet sorghum and sugarbeet as feedstocks in India

Particulars	Sugarcane	Sweet sorghum	Sugarbeet
Sugar content (%)	11-12	10-14	12-15
Ethanol yield (L/ha)	700-800 (1) (from molasses)	1,400 (2)	6,000-6,400 (3)
Cost of ethanol production (Rs/L)	24-32(4)	17-19(5)	12-14(6)
Crop duration (months)	12-16	4	5-6
Water requirement (m^3 /ha/crop)	20,000-30,000	4,000	8,000-10,000
Fertilizer requirement (NPK kg/ ha)	250:125:125	80:50:40	120:60:60

Notes:

(1) 2.8-3.4 t / ha of molasses @ 250 L / tonne. Direct conversion of sugarcane juice to ethanol can yield around 4800-6000 litres/ ha (FAO, 2008).

(2) Two crops of sweet sorghum can be taken per year. Yield of millable @35 tonnes/ha/crop and ethanol yield @ 40 L / tonne (Reddy et al., 2005)

(3) 75-80 tonnes / ha of sugarbeet @ 80 L / t

(4) *Source*: NCAP Field Survey, 2010. Cost of molasses ranges between Rs 3500/t and Rs 5000/t

(5) *Source*: ICRISAT (2009). Cost of sweet sorghum stalk @ Rs 500-600 / t

(6) *Source*: Revised based on TNAU (2009). Cost of sugarbeet @ Rs 700 / t

[10] One crop of sweet sorghum yields around 1400 litres of ethanol per ha. Two crops can be taken in a year but the yield of the second crop depends on provision of supplementary irrigation and availability of appropriate variety for the second season.

However, the field trials conducted by Tamil Nadu Agricultural University (TNAU) have shown that tropical sugarbeet can be successfully cultivated in India on large-scale. Sugarbeet is a crop of 5–6 months duration and grows well in sandy loam soil. The ability of this crop to thrive well in saline and alkaline soils is of special significance. Ethanol can be directly produced from the sugarbeet juice at an average recovery rate of 80–90 litres of ethanol/tonne of sugarbeet. At this rate, the ethanol yield from sugarbeet (6000–6400 litre/ha) is far higher than from sugarcane molasses and sweet sorghum, and can be realized at a very low cost of production (Rs 12–14/litre) (Table 9).

Above all, by shifting from sugarcane to sugarbeet, around 10,000–20,000m^3 of water/crop can be saved. Sugarbeet can also be explored as a source of sugar in addition to ethanol as it contains higher sugar content. Concurrently, the country has to look for improved technology and management practices to maximize the efficiency from the existing feedstocks. Lower plant capacity, use of batch process technology, inefficient byproduct and effluent management practices, etc. are among the major technological constraints faced by the industry currently. Long-term technological targets like biotechnological applications to increase the sugar content of crops, commercial use of microbes and membranes, etc. should also be devised (Raju *et al.*, 2009). Research has shown that ligno-cellulosic biomass sources like bagasse, cereal crop residues, forest thinnings, saw dust, paper, etc. can also serve as excellent feedstocks for bioethanol production. However, the commercial feasibility and viability of such feedstocks are yet to be ascertained and the production costs are likely to be much higher than conventional feedstocks (requiring significant subsidies to remain competitive with other fuels). Therefore, in order to realize this goal, a shift in the focus of research towards developing lower-cost second generation biofuels is needed along with sufficient (and sustained) political resolve to make adequate investments. The government should also take efforts to reflect the changing priorities in its policies.

4.4 Potential of Biodiesel Production

Biodiesel is emerging as an important bioenergy option for India. There is a scope to increase biodiesel production by tapping the existing resources of TBOs in the country as well as by taking up new plantations. The efforts for biodiesel production are focused on using non-edible oils obtained from *jatropha, pongamia,* and other TBOs. The focus is on encouraging the use of wastelands and other unproductive lands for the cultivation of these relatively hardy 'new' biofuel crops. The Government of India does not want the biofuel feedstock crop cultivation to compete with food crops for scarce agricultural land and water. The Government of India policy is also driven by the vast rural population in India, considering their needs for food security and gainful employment. There is some concern about the definition of 'wastelands' as some grazing or less-intensive dryland farming may be taking place on these 'wastelands'. Nevertheless, commercial-scale biodiesel production from non-edible oilseeds, etc. is still at the research and development stage in India.

The NBM has identified *jatropha* as the most suitable tree-borne oilseed crop for biodiesel production in India. The Planning Commission report on development of biofuels has also officially endorsed the suitability of *jatropha* as a prominent feedstock for biodiesel production in India (GoI, 2003). Even though various other oilseed crops also qualify as feedstocks for biodiesel production, *jatropha* has been specifically chosen, it being a short-gestation, non-edible oilseed crop which does not impinge on the food security of the nation even if promoted commercially. Also, *jatropha* is a drought-tolerant and hardy crop which can be grown in a relatively less fertile and marginal lands with minimal inputs and management. Several other TBOs like *pongamia, simaruba*, *neem, mahua,* etc. have also been found suitable and are being promoted but are less favoured than *jatropha* owing mainly to their long gestation periods. Several studies (Tilman *et al.,* 2009; Fargione *et al.,* 2008) at the global level have also favoured *jatropha* over other crops for cultivation in marginal or less-productive lands for biodiesel production. On a global level, considerable investments are being made on the *jatropha*-based biodiesel development projects. A survey conducted by the Global Exchange for Social Investment (GEXSI, 2008) has identified 242 *jatropha* projects in different parts of the world and the majority of them are located in Asia. India is currently the leading cultivator of *jatropha* with nearly 0.5 million hectares (M ha) of area under this crop.

The demand has also been increasing for diesel at the rate of 7.5 per cent per annum since 2004-05. Demand projections suggest that nearly 3.21 million tonnes (Mt) of biodiesel would be required for 5 per cent blending by the year 2011-12 (Table 10). To bring this into effect, and assuming that *jatropha* would be the major feedstock for biodiesel (i.e., 80 % of the requirement would be met from *jatropha*) with an average seed yield[11] of 2.5 t/ha and 30 per cent biodiesel recovery rate, the area required under the crop has been worked out to be 3.42 Mha. An estimated area of 26.25 M ha would be required under *jatropha* to meet 20 per cent blending target by the year 2020-21, if the yield and oil content of *jatropha* remain the same and if no new superior feedstocks are introduced. So far in the country, only around 0.5 M ha land has been put under *jatropha* cultivation and the government has not initiated purchasing of biodiesel through the designated purchase centres even though MPP of Rs 26.50 per litre was announced a few years ago. Presently, *jatropha* seeds are mainly crushed for oil at the village level or in small-scale plants for local use or for sale to the unorganized sector.

Table 10: Projections of biodiesel demand and corresponding jatropha **area required for meeting the blending targets in India**

(Area in M ha, Demand in Mt)

Year	Diesel demand	For 5 % blending		For 10 % blending		For 20 % blending	
		Biodiesel demand	Jatropha area	Biodiesel demand	Jatropha area	Biodiesel demand	Jatropha area
2011-12	64.19	3.21	3.42	6.42	6.85	12.84	13.69
2016-17	92.15	4.61	4.91	9.21	9.83	18.43	19.66
2020-21	123.06	6.15	6.56	12.31	13.13	24.61	26.25

Note: The compound annual growth rate during the five years ending 2008-09 for diesel demand (7.5 %) was used for trend projections.
Source: Shinoj et al. (2011a)

4.4.1. Availability of Land for Biodiesel Crops

The availability of land is the basic requirement for large-scale plantations of biodiesel crops. Several private industries and state

[11] The NCAP survey conducted at Rajasthan, Chhattisgarh and Uttarakhand suggests that the average yield of *jatropha* under normal management practices in farmers' field ranges between 2.0 and 2.9 t/ha.

Governments are exploring the possibility of utilizing agricultural land as well for biodiesel production. Biodiesel plantation on wastelands mainly depends on two factors: availability of wastelands and suitability of different agro-ecological regions for biodiesel plantations.

The 1995 report of the high level Mohan Dharia Committee on Wastelands Development analyzed the land use statistics available for 305 M ha out of 329 M ha land area of the country, and noted that there was much confusion regarding the extent of wastelands, as Table 11 demonstrates. In addition, as per the recent Wastelands Atlas of India (NRSA, 2000), about 63.85 M ha of the area can be classified as wasteland (including 14.06 M ha of degraded notified forest lands). As the Mohan Dharia Committee has pointed out, the confusion arose from differing definitions of wastelands used by various agencies; also because these agencies failed to distinguish between lands which had gone out of productive use because of extreme degradation and lands which were still in use although these too were degraded to some extent.

Table 11: Various estimates of wastelands in India

Source	Area (M ha)
National Commission on Agriculture (NCA-1976)	175.0
Directorate of Economics and Statistics, Department of Agriculture and Cooperation	38.4
Ministry of Agriculture (1982)	175.0
Department of Environment and Forests (B.B. Vohra)	95.0
National Wasteland Development Board (Ministry of Environment and Forests, 1985)	123.0
National Bureau of Soil Survey and Land Use Planning, ICAR-1994	187.0
Society for Promotion of Wasteland Development (SPWD-1984)	129.6
National Remote Sensing Agency (NRSA-1995)	75.5
Dr. N.C. Saxena (Secy. RD-WD)	125.0

Source : Eswaran (2001)

Another point worth noting with regard to the land availability issue is that it would not be correct to assume that the entire

63.85 M ha of wasteland, based on the Wastelands Atlas of India (NRSA, 2000), for example, would be available for raising biofuel plantations under the National Biodiesel Programme. No estimate has so far indicated the number of people who live in the different categories of wastelands or how they use them, and its relevance for sustainability. Some authors have raised concern that biofuels (and other agribusiness ventures) could inadvertently deprive the disadvantaged groups of access to important common lands (needed for grazing, fuelwood collection, etc) and cause deterioration of their livelihoods and socio-economic status (von Braun and Meinzen-Dick 2009).

Table 12: Planning Commission estimates on potential land availability for *jatropha* plantation

Type of land	Total area (M ha)	Area for *jatropha* plantation (M ha)	Assumptions
Forest cover	69	3	14 M ha of forests are under the scheme of Joint Forest Management out of which 20 per cent would be easily available for *jatropha* plantation.
Agricultural land	142	3	It is assumed that farmers will like to put a hedge around 30 M ha for protection of their crops.
Agro-forestry		2	Considerable land is held by absentee landlords who will be attracted to *jatropha* plantation as it does not require looking after.
Cultivable fallow lands	24	2.4	10 per cent of the total area is expected to come under *jatropha* plantation.
Wastelands under watershed development and other poverty alleviation programmes of MoRD		2	---
Public lands along railway tracks, roads and canals		1	----

Source : Planning Commission (2003).

Though productive use of wastelands is considered as an important component of the agricultural strategy in the mid-term appraisal of the Tenth Plan, ownership of wasteland becomes an important issue. The Approach Paper to the Mid-Term Appraisal notes that in both forest and Government-owned wastelands, it is difficult to involve local communities unless land ownership is given to them. In addition, while the government may be able to promote plantation of TBOs on government or community land, for the privately owned wastelands it would not be possible unless the farmers are offered assured returns or convinced of the financial viability of the biodiesel plantations. Therefore, there is a need to exercise caution before one makes any assumption about the potential use of existing wastelands for raising biodiesel plantations.

The Planning Commission (2003), Government of India, has estimated that with appropriate extension and availability of planting stocks, it would be possible to cover 13.4 M ha of land with *jatropha* by the year 2012, so as to meet the emerging blending requirements. The details of estimation are given in Table 12. However, *jatropha* plantations have been slow to take off due to the lack of good quality planting materials and ownership issues of community or government wastelands and other factors (Kureel, 2007). Agriculture being a state subject, the responsibility for the promotion of *jatropha* plantation rests with the state governments. Biofuel plantation programme is in dire need of integrated approach across various states. While the authority for transfer or leasing of government land rests with the district collector, the nodal agency for processing of application differs in each state. The type of land made available for plantation also varies across different states (Table 13).

Table 13: Initiatives taken by some states for *jatropha* plantations

State	Nodal agency	Type of land made available
Rajasthan	Department of Agriculture	Wastelands and ravine lands
Andhra Pradesh	Department of Rain and Shadow Area Development	Irrigated and rainfed lands
Tamil Nadu	Watershed Development Agency & Watershed Development Corporation	Wastelands and degraded forest lands
Chhattisgarh	Biofuel Development Authority	Wastelands or ravine lands
Gujarat	Agro Industrial Corporation	Hilly areas and barren lands

Source: Saxena (2007)

4.4.2. Availability of Planting Stocks

Jatropha can be propagated by both seeds and cuttings. But as the demonstration phase of the NBM proposes to establish 400,000 hectares of *jatropha* plantations, the choice of planting stock will necessarily be seed, because cuttings would not be available in such a huge number. For planting one hectare of land at a spacing of 2m x 2m (i.e., 2,500 plants per hectare), 5 kg seeds are required. A total of 2,000 tonnes of seeds would be required for raising plantation on 400,000 hectares. Additionally, planting stocks will be required for entrepreneurs, private farmers and the *jatropha* programmes of several state governments. Though the quantity of the seeds may not be a problem, the price could be high. At present, *jatropha* seeds are being sold at a premium price of Rs 8-10 / kg. This might increase further once the programme is launched. It would also be essential to ensure that the seeds used are of high purity and have a high germination rate. For this, selection of superior germplasm from the existing population and getting seeds with superior genetic quality should be the priority.

4.5 Assessing Performance of *Jatropha* at Farm Level: A Primary Survey

In order to further understand the socio-economic implications of *jatropha* cultivation at farm-level and the upcoming *jatropha*-based biodiesel value chain in the country, a primary study[12] was designed and carried out by the NCAP team in the year 2010 in three major *jatropha*-growing states, namely, Rajasthan, Chhattisgarh and Uttarakhand. An exclusive account of this study is available in Shinoj *et al*. (2010).

4.5.1 Data and Methodology

The study was predominantly based on the survey data collected from three major *jatropha*-cultivating states, namely Rajasthan, Chhattisgarh and Uttarakhand using pretested questionnaires. The primary data pertained to the cost of cultivation, yields, input

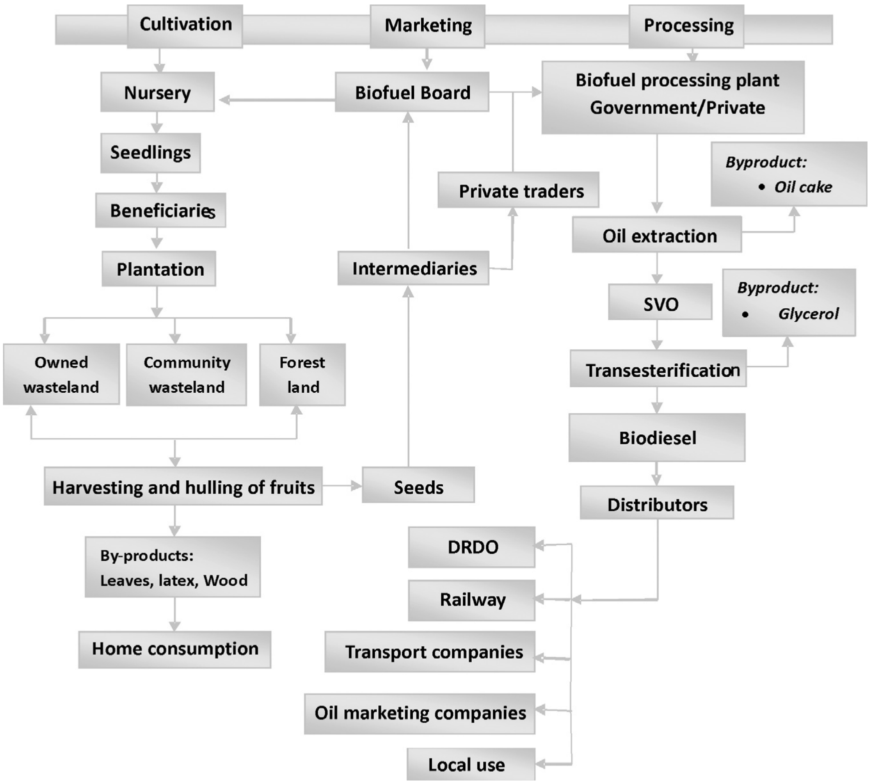
[12] The questionnaires used for data collection from the *jatropha* farmers and processing industries are provided in Annexures 2 and 3, respectively.

sources, marketing practices and other economic and livelihood aspects regarding *jatropha* cultivation. From each state, one district each (Sikar in Rajasthan, Bilaspur in Chhattisgarh and Dehradun in Uttarakhand) and then two blocks within it were selected purposively based on the prominence of *jatropha* plantations. Three villages from each block, i.e. six villages from each district were selected and finally ten *jatropha*-growing farmers from each village were chosen randomly as respondents for conducting personal interviews. The detailed sampling design is provided in Annexure 5. In all, 60 sets of *jatropha* plots were sample from each state. The socio-economic profile of the sample farmers has been presented in Annexure 6. The NCAP study team also visited two biodiesel manufacturing units, one each in Rajasthan and Chhattisgarh, to obtain detailed information on *jatropha* processing aspects. In addition, information collected through personal meetings and discussions with various state department officials, *panchayat* committee members, faculty of agricultural universities, market intermediaries and corporate officials was also used. In addition, various secondary sources like published reports and websites were also relied upon. Tabular and graphical methods have been used to present the results in the following sub-sections.

4.5.2 The *Jatropha* Value Chain

The *jatropha* value chain consists of various activities starting from raising of nursery to distribution of biodiesel to the end-users. Broadly, the activities can be classified into four categories, viz. farm production of seeds, seed marketing, biodiesel production, and biodiesel distribution. A schematic representation of a typical *jatropha* value chain has been depicted in Figure 6. Various stakeholders like government, producer farmers, market intermediaries, traders, biodiesel processers, distributors and consumers are involved in the *jatropha* chain, though minor regional variations were observed. The following section provides detailed discussions on the major activities in the *jatropha* value chain.

Figure 6 : A typical *jatropha*-based biodiesel value chain: Schematic representation



DRDO: Defence Research and Development Organization

SVO: Straight Vegetable Oil

4.5.3 Farm Production of *Jatropha* Seeds

4.5.3.1 Farming Models

Farm production of *jatropha* seeds is the first major activity in the value chain. Different models of *jatropha* cultivation were observed in the selected states and are presented in Table 14. The widely seen model was the farmer-centric cultivation model wherein farmers cultivate *jatropha* on their own lands with some government assistance like provision of subsidized seedlings and other inputs, extension support, etc. This was predominant in the Sikar district of Rajasthan and the Bilaspur district of Chhattisgarh, where the surveys were conducted. Another common model was the government-mediated production wherein the community wastelands are leased out to local SHGs or JFMCs. The farmers, as members of SHGs or JFMCs, are granted rights to cultivate and harvest *jatropha* seeds. Various government bodies like National Oilseeds and Vegetable Oils Development Board, state biofuel boards[13], forest departments, etc. are instrumental in sustaining the activities. The government extends substantial encouragement to the farmers by providing free or subsidized seedlings and other inputs like fertilizers and manures, follow-up and monitoring support for plant maintenance, marketing support, etc. Also, the labour involved in the initial establishment is being sourced under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) by paying mandatory wages. This practice is under operation in 11 districts of Rajasthan, 9 districts of Uttarakhand and several districts of Chhattisgarh. A number of recognized NGOs are also active participants in this model of cultivation, by being involved in different promotional activities.

Table 14: Different models of *jatropha* cultivation at farm level in selected states of India

Operator	Land ownership	Rights on harvest	Government role
Farmer	Farmer	Farmer	Subsidy on seedlings
Farmer (SHG/ JFMC)	Community	SHG/JFMC	Lease of land, subsidy on inputs, employment guarantee
Corporate	Private/ Community	Corporate	Incentives for setting up processing plants

The third was the corporate, business-oriented model of cultivation. *Estate Farming* and *Contract Farming* were the two variants within this model. In the *Estate Farming* model, large corporate companies like D1 Mohan Bio Oils Ltd., Nandan Biometrics, etc. cultivate *jatropha* in either their own land or community land leased-in from the local *panchayats*. In this model, the company employs the local villagers to cultivate

[13] Biofuel Authority (BFA) in Rajasthan, Chhattisgarh Biofuel Development Authority (CBDA) in Chhattisgarh and Uttarakhand Biofuel Board (UBB) in Uttarakhand.

the crop and the right to harvest rests with either the company or is shared with the *panchayats*. *Contract Farming* mode of operation with buy-back arrangements with the farmers was also found to be prevalent in some parts of *jatropha*-growing states. In this mode, the company provides inputs, technical guidance and other extension services during the initial years of establishment. The contracts can be reached either at a pre-determined price for the seeds or just with the understanding that the company will purchase the seeds at the prevailing market price. Some public sector undertakings like Indian Oil Corporation (IOC), Oil and Natural Gas Corporation (ONGC) and private bodies like Indian Farmers Fertilizer Cooperative Limited (IFFCO) have also recently entered into contract farming arrangements with the farmers.

4.5.3.2 Agronomic and Economic Performance at Farm Level

The analysis of data on farm households suggested that the majority of *jatropha* farmers in the survey area were marginal and small farmers. Some medium farmers were also involved in growing of *jatropha,* but large farmers were totally absent. In Uttarakhand, only marginal farmers were involved under government-mediated *jatropha* cultivation. The average plot size was of less than one quarter of a hectare in Rajasthan and a little more than half a hectare in Chhattisgarh. The highest area under SHG in Uttarakhand was of 8 ha, and the lowest was of 2 ha with an average size of 3.87 ha (Table 15). Age of the seedlings had crossed three years in Rajasthan, nearing 3 years in Chhattisgarh and was more than four years in Uttarakhand. Fairly good seedling survival rates were noticed in Rajasthan and Chhattisgarh, while moderate survival rate of 61 per cent was observed in Uttarakhand. The yields were more or less similar across the states and farm-categories and were between 2-3 tonnes per hectare at third year. Even though wide ranges in yield have been reported for *jatropha*, our results were consistent with the yield estimates reported under moderate management conditions (Paramathma *et al.*, 2009).

Table 15: Details of *jatropha* cultivation at farm level in selected states

State	Farmer category©	Area under *jatropha* (ha)	Age of seedlings (year)	Number of seedlings in planted area	Survival rate of seedlings (%)	Yield (t/ ha)
Rajasthan	Marginal (26)	0.08	3.4	148	73	2.01
	Small (22)	0.10	3.0	191	79	2.41
	Medium (12)	0.26	3.6	558	84	2.92
Chhattisgarh	Marginal (6)	0.72	2.8	2633	86	2.52
	Small (36)	0.60	2.7	1535	87	2.62
	Medium (18)	0.72	2.7	1630	84	2.70
Uttarakhand	Marginal (60)	3.87*	4.5	7950	61	2.22

* Community area allotted to self-help groups where marginal farmers were growing *jatropha*.

© Marginal: Less than 1 ha; Small: 1 to <2 ha; Medium: 2-10 ha. Figures within the parentheses indicate number of farmer-respondents in each category

The initial establishment activities of *jatropha* cultivation during the first three years were found to create employment for 85-108 man days in the selected states under moderate management conditions (Table 16). An additional 1 man day labour per 50 kg of pods harvested was required from the third year onwards. Therefore on an average, around 40-50 man days would be created per hectare per year as the plants start yielding, and it would further increase as the plants reach maturity. In all sample households, more than 80 per cent of the employment created in *jatropha* cultivation activities was catered from within the family. In all the three states, farmers were found to apply fertilizers and manures only in the first year. The farmers applied both manures and fertilizers in Rajasthan, while in the other two states they applied only manures. The plants were irrigated during the initial 2-3 years, but with varying intensity in different states. In Rajasthan, around 40 per cent farmers irrigated three or more times during the initial years, while 48 per cent famers irrigated twice and rest 12 per cent only once. In Chhattisgarh, around 43 per cent farmers irrigated twice, while 57 per cent irrigated only once in the first year. In contrast, in Uttarakhand, all farmers irrigated only once in the first year, leaving the crop rain-fed in the rest of the years. None of the farmers in any of the locations was found to follow any crop protection measures.

Table 16: Input application pattern during initial period of establishment of *jatropha* in survey plots

State	Labour (man days/ha)*			Manure (t/ha)	DAP£ (kg/ha)	Per cent farmers¥ irrigating/year		
	Family	Hired	Total			Once	Twice	Thrice or more
Rajasthan	90	18	108	1.90	150	12	48	40
Chhattisgarh	85	12	97	1.60	0	57	43	0
Uttarakhand	71	14	85	0.80	0	100	0	0

Notes: Farmers applied manures and fertilizers only in the first year in all the three states.

*Labour incurred during first three years for planting, fertilizer and manure application, irrigation, etc.

£ Only 35 per cent of the farmers applied fertilizer (di-ammonium phosphate) while planting *jatropha* in Rajasthan.

¥Figures for Chhattisgarh and Uttarakhand apply only for the first year.

The economics of *jatropha* cultivation was found to vary considerably depending upon the cultivation model and location, as is evident from the cost of cultivation figures for the three selected states presented in Table 17. While Rajasthan farmers incurred a cost of around Rs 31,295/ha, during the first year, the estimates for Chhattisgarh and Uttarakhand were Rs 8,321/ha and Rs 12,050/ha, respectively. This can be attributed to the inter-state variations in subsidies on seedlings and other inputs, variations in labour charges, differential usage of inputs, etc. The farmers in the Sikar district of Rajasthan had to pay Rs 6-10 per seedling as they did not get any subsidy from the state government[14]. The cost of seedling alone was around 35 per cent

[14] Rajasthan government provides jatropha seedlings at subsidized rate under the government-mediated jatropha cultivation programme operational in only 11 districts, in which Sikar district does not fall.

of the total cost. In contrast, Chhattisgarh farmers were getting seedlings at a highly subsidized rate of Rs 0.50 per seedling and the Uttarakhand farmers were being provided hundred per cent subsidy on seedlings. Wage rate was another major component of cultivation cost and it also varied across states (wage rates in Rajasthan, Chhattisgarh and Uttarakhand were Rs 150, Rs 50 and Rs 120 per day, respectively). These differences also got manifested in profits, pay back period, etc. and indicated the differential level of incentives for *jatropha* cultivation at different locations in India.

Table 17: Economic analysis of *jatropha* cultivation in selected states of India

(Rs/ha)

Particulars	Rajasthan			Chhattisgarh			Uttarakhand		
	I year	II year	III year onwards	I year	II year	III year onwards	I year	II year	III year onwards
Land preparation	1125	0	0	375	0	0	900	0	0
Digging pits	5625	0	0	2125	0	0	4800	0	0
Sapling cost	11250	1500	0	1065	225	0	0	0	0
Planting	3000	375	0	1125	375	0	2400	0	0
Manuring	3125	0	0	2375	0	0	2400	0	0
Fertilizer	3325	0	0	0	0	0	0	0	0
Irrigation	1000	1000	1000	500	0	0	500	0	0
Harvesting	0	0	6750	0	0	2500	0	0	5400
Sub-total	28450	2875	7750	7565	600	2500	11000	0	5400
Incidentals (10%)	2845	288	775	756	60	250	1050	0	540
Total cost	31295	3163	8525	8321	660	2750	12050	0	5940
Returns	0	0	17812	0	0	17875	0	0	13500
Net profit	-31295	-3163	9288	-8321	-660	15125	-12050	0	7560

Notes: The figures are averages across sample farmers.
Wages: Rs 150, Rs 50 and Rs 120 for Rajasthan, Chhattisgarh and Uttarakhand, respectively.
Cost of saplings: Rs 6.00 and Rs 0.50 per seedling in Rajasthan and Chhattisgarh, respectively, 100 per cent subsidized in Uttarakhand.
Cost of fertilizer: Rs 9.50 / kg of DAP and manure @ Rs 500 per tonne.
Cost of irrigation: Rs 500 per irrigation per hectare
Price of *jatropha* seeds: Rs 7.50/kg in Rajasthan, Rs 6.50/kg in Chhattisgarh and Rs 6.00/kg in Uttarakhand including overhead charges on seed collection.

The above analysis shows that the break-even period and profitability of *jatropha* cultivation depend on the level of government support to the programme in the initial years. In the selected district of Rajasthan, it would take 6-7 years for the farmers to cover the initial establishment cost as opposed to the Chhattisgarh and Uttarakhand farmers who start realizing profits respectively from the third and fourth years onwards. Since most of the *jatropha* cultivators fall under the categories of marginal and small farmers, who do not have other major off-farm sources of income, the government support in the initial years is crucial.

Considering the long-term nature of investment in *jatropha* cultivation, a few discounted measures of financial assessment like Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR) were worked out for the selected states and are presented in Table 18. The long-term prospects of *jatropha* cultivation were found promising in all the three states due to low recurring costs associated with farm management[15]. In relative terms, the farmers of Chhattisgarh would benefit more than those of other two states due to lower initial investment, minimal input usage and lower wage rates prevailing in this state. However, it is cautioned that this analysis would hold only if the current parity of seed prices is maintained in future also.

Table 18: Financial measures for assessing the feasibility of investment in *jatropha* cultivation in three states of India

State	NPV (Rs)	BCR	IRR (%)
Rajasthan	47310	1.47	25
Chhattisgarh	100265	10.18	85
Uttarakhand	48743	1.81	45

Note: The economic life-span of *jatropha* was assumed to be 20 years; A 10 per cent discount rate was used for the calculations.

None of the sample farmers in any of the three states reported any case of crop land being substituted for *jatropha* cultivation. Farmers who cultivated *jatropha* in their own lands used only waste or fallow lands that were previously lying unused. Some farmers

[15] The future costs were worked out based on the present package of practices being followed by the farmers as obtained from the surveyed data.

cultivated *jatropha* as fences around the crop lands. Some farmers in Rajasthan and Chhattisgarh did express concern about the loss of grazing land for cattle due to *jatropha* cultivation, it being an animal deterrent crop. The loss of common grazing land could result in the shortage of fodder and thus could negatively affect the livestock economy in the *jatropha*-growing areas, as has been reported in a recent study conducted in Tamil Nadu by Ariza-Montobio and Lele (2010). A majority of the farmers were of the opinion that the currently available germplasm is low-yielding with long gestation period and the government has to take necessary steps to develop high-yielding varieties. They also believe that the full yielding potential of *jatropha* cultivation would only be realized when adequate irrigation and fertilizers are made available; presently, it is not a profitable proposition due to low prices of *jatropha* seeds. The ability of *jatropha* to prevent soil erosion in the hilly terrains was also brought into notice. In nutshell, the farmers considered *jatropha* not as a major profit winning crop but only a supplementary crop that provided them with additional employment and income, provided that there is government support during the initial years of establishment.

4.6. Seed Marketing

The farm-produced *jatropha* seeds take different routes to reach the processing plants. Largely three types of actors are involved in this activity: (i) government agents who collect the seeds on behalf of the state biofuel boards or government-owned processing plants, (ii) local traders who collect the seeds and then supply to the processing plants or their agents, and (iii) corporate agents who collect seeds directly from the farmers.

Table 19: Various agencies involved in marketing of *jatropha* seeds

State	Share of seeds marketed (%)		
	Government agents	Local traders	Private companies
Rajasthan	0	100 (7.5)	0
Chhattisgarh	50 (6.5)	0	50 (10.0)
Uttarakhand	100 (6.0)	0	0

Note : Figures within the parentheses indicate prices received by farmers in Rs/kg

[16] The Rajasthan State Mines and Minerals Ltd. (RSMML) owned *jatropha* processing plant at Udaipur.

In the Sikar district of Rajasthan, all the respondent farmers sold the seeds to local traders only (Table 19). In most cases, petty shopkeepers were involved in the collection of seeds from the farmers; they either transported seeds to processing plants or sold to the company agents who procured the seeds in bulk. At some instances, these seeds were even transported to Chhattisgarh to be used in raising nurseries for new plantings. In Chhattisgarh, farmers in the Kota block of Bilaspur district sold seeds to government agents, while those of Marwahi block marketed the seeds to the private company agents. The farmers could get a higher price of Rs 10.00/kg for their seeds from the private company, but they got only Rs 6.50-7.00/kg when they sold the seeds to the government agents. The State Biofuel Boards also used the seeds for both processing and raising new plantations. In Uttarakhand, where the government mediated production was dominant, farmers sold the seeds only to the government agents at a price of Rs 6.0/kg. It was noted that in places where local traders were involved in *jatropha* seed procurement, the marketing margin was considerably high. In Rajasthan, the price at which the processing plant[16] purchased the seeds from traders was around Rs 12.00-13.00/kg, whereas the farmers sold the seeds at the rate of Rs 7.50 to Rs 10.00/kg, depending on the locality. It means that the marketing margin between the farmers and the processing plant was around Rs 3.00- 5.50/kg. This margin included the traders profit and costs on transportation and handling. To avoid this extra margin, some private processing plants were procuring the seeds directly from the farmers by paying a higher price, as was observed in the case of Chhattisgarh.

4.6.1 Seed Processing and Biodiesel Production

Seed processing infrastructure is one of the key requirements in the *jatropha* seed-based biodiesel value chain and is presently a major constraint holding back the development of the biodiesel sector in India. In most of the *jatropha*-growing areas, modern processing plants have not come up in sufficient numbers so far. It is because of two major reasons; first, the government intends to bring private participation to build this capacity but the private players visualize potential risks in investing in this area because of uncertainty regarding the supply of sufficient feedstock and market demand for biodiesel. Second, the unavailability of processing capacity is making the farmers to down-scale their production and this poses a threat to even the existing processing plants. The cost of production of biodiesel increases substantially if the units are run under low economies of scale. The problem worsens with increase in the price of seeds due to the involvement of middlemen and higher transportation costs when the seeds are sourced from distant places. To substantiate these points, the cost of production of biodiesel in two processing plants, viz., Rajasthan State Mines and Minerals Ltd. (RSMML) biodiesel plant in Udaipur and Chhattisgarh Biodiesel Development Authority (CBDA) processing plant at Raipur was compared in the study [17].

The physical and monetary details regarding input requirement per day and the corresponding production of biodiesel and other byproducts in the two manufacturing plants have been presented separately in Table 20. It was observed that the RSMML plant crushed 1 tonne of *jatropha* seeds while the CBDA plant processed 10 tonnes of seeds with respective biodiesel yields of 250 kg and 2730 kg. The cost of biodiesel production in RSMML facility was around Rs 40/kg, whereas in CBDA unit it was nearly Rs 19.00/kg, the difference being significant. However, there were multiple reasons behind the cost difference. In Rajasthan, the cost of seeds at factory gate was around Rs 12/kg because of the reasons stated above. In contrast, the CBDA unit could procure the seeds at Rs 6.50/kg directly from the farmers and incurred nominal costs on handling and transportation as sufficient seeds were available in the nearby locality. In addition, the economy of scale favoured the CBDA processing plant in bringing down the cost in comparison with the RSMML plant. The RSMML plant also faced shortage of seeds in spite of the fact that sufficient seeds are produced in Rajasthan, the reason being diversion of seeds for nursery rising under government support. Due to all these constraints, the RSMML plant is on the verge of closure and currently uses the produced biodiesel in the company's own fleet of trucks.

[17] In Uttarakhand, a transeterification unit of capacity 50 Mt per day oil has been established by Uttarakhand Biofuel Ltd. (UBL) at Haridwar. However, since the study team could not gain access to their data, details are not presented here.

Table 20: Cost of production of biodiesel in Rajasthan and Chhattisgarh-A comparative study

Inputs	RSMML plant		CBDA plant	
	Quantity	Value (Rs)	Quantity	Value (Rs)
Jatropha seeds	1 tonne / day	12000	10 tonnes/ day	65000
Unskilled labour	2 man days	300	6 man days	720
Managerial labour	1 man day	450	1 man day	600
Administrative labour	1 man day	250	4 man days	1600
Chemicals				
1.Methanol	60 litres	630	600 litres	6600
2. Sodium hydroxide	2 kg	50	21 kg	540
Electricity	25 units	250	250 units	2500
Interest on fixed capital	@ 10%	650	@ 10%	6800
Depreciation on machinery	@ 10 %	270	@ 10 %	1700
Depreciation on other assets	@ 4 %	440	@ 4 %	2740
Freight and other incidentals		350		6500
a. Total cost		**15640**		**95300**
Revenue from byproducts				
Glycerol	46 kg	1380	467 kg	10274
Oil cake	700 kg	4200	6750 kg	33750
b. Total revenue		**5580**		**44024**
Net cost incurred (a-b)		10060		51276
Recovery of biodiesel	250 kg		2730 kg	
Net cost/kg of biodiesel		**40.24**		**18.78**

The above discussion makes it clear that, if processed at sufficient levels of economies of scale, as in the CBDA processing plant, *jatropha*-based biodiesel is economically viable and can substitute petro-diesel. The technology would prove more profitable in the event of further hikes in the price of crude oil, the probability of which is very high. However, it is mandatory to build up the necessary infrastructure in places where the feedstock crops are growing well and where a future potential is visible. In this context, private sector has a major role to play. Several private companies like Nova Biofuels, Panipat; Emami Biotech, West Bengal; Universal Biofuels, Andhra Pradesh; Royal Energy, Mumbai and many others have already shown their presence in the field. A demand pull arising out of mandatory blending requirement can be a strong stimulus to such initiatives. But even though a necessary step, it is not sufficient to sustain the momentum in developing the sector, rather developing a full-fledged value chain, from farm production of *jatropha* seeds to distribution of biodiesel is equally important and critical. The next section outlines the current state of affairs regarding the identified biodiesel distribution chains in India in general and in the selected states in particular.

4.7 Biodiesel Distribution

Presently, the biodiesel distribution does not follow any well-developed supply chain, even though several public sector undertakings and private companies have ambitious plans to enter into the sector in a big way. As of now, the consumers of biodiesel in the country include Indian Railways, Defence Research and Development Organization (DRDO), state road transport corporations, some private companies, etc. Other than this, the local consumption in tractors, trucks, diesel pump sets, etc. is also prevalent. Public sector OMCs like Hindustan Petroleum (HP), Bharat Petroleum (BP), IOC and ONGC are in the process of setting up extensive network of biofuel distribution chain connecting various processing industries and retail outlets across the country. However, presently they are concentrating more on developing *jatropha* plantations through contract farming arrangements involving local governments and farmers. Some efforts of establishing commercial tie-ups with private companies for setting up processing capacity are also underway.

The Indian Railways have started using 5 per cent blend of biodiesel in narrow gauge engines. A separate body 'Indian Railways Organization for Alternate Fuels' (IROAF) instituted under the Indian Railways is building networks with potential biodiesel suppliers like Southern Online, Hyderabad and Royal Energy, Mumbai. Several state transport corporations like Andhra Pradesh State Road Transport Corporation (APSRTC), Navi Mumbai Municipal Transport Corporation (NMMTC), Uttar Pradesh State Road Transport Corporation (UPSRTC), Calcutta Tramways Company Ltd, etc. have also started blending biodiesel with HSD in their fleet of buses. The Kolkata Police Department has tied up with Emami Biotech for regular supply of biodiesel to be used in their wireless fleet.

In Rajasthan, the Rajasthan State Mines and Minerals Ltd. (RSMML) is the only major *jatropha* oil processing unit, though some smaller oil expelling units are also working locally. RSMML utilizes the produced oil only in its fleet of trucks due to lack of cost-effectiveness in production. The Rajasthan State Road Transport Corporation (RSRTC) is sourcing biodiesel from some local small-scale biodiesel units to conduct pilot runs in their buses. Along with this, some farmers are using Straight Vegetable Oils (SVO) made from *jatropha* in their tractors and diesel pumps. The CBDA processing plant in Chhattisgarh is supplying the biodiesel produced in its unit to Indian Railways, DRDO, Mahindra and Mahindra Ltd. and to some transport companies within the state. Some village electrification committees based in Chhattisgarh are also using biodiesel to cater the local electricity needs. In Uttarakhand, commercial use of biodiesel is yet to be started. Currently, it is only used for meeting local energy needs.

4.8 Summing-up

It is clear from the above discussions that the development of a commercial biodiesel industry based on *jatropha* and other non-edible oilseeds is at a primordial stage in India at present. The farm surveys have suggested that the farmers are not content with the current yield of the crop. To address this constraint, identification of superior germplasm with high-yield potential through systematic varietal improvement programmes is a pre-requisite to large -scale planting. A centrally coordinated breeding programme that replaces the current piecemeal approach in research can pay high dividends. It is also widely felt that *jatropha* is not a fully domesticated crop and cannot be grown successfully in all kinds of marginal lands.

Unscrupulous planting irrespective of the geographical and climatic contours, can only sabotage the programme. Most of the *jatropha* growing farmers being marginal and small are resource-poor, and therefore initial support in the form of subsidized seedlings and other inputs, technical assistance, buy-back assurance, MSP, etc. is of utmost importance for the success of biodiesel production. Premature withdrawal of support facilities may also jeopardize the programme.

Economic viability of *jatropha* plantations is critical in retaining the interest of the farmers. Higher prices of seeds are being realized presently because of their demand for seedlings of new plantings. However, once this phase is over, there is every chance of prices going down unless a *jatropha* seed market with both backward and forward integrations is evolved. The probability of the programme to topple down would be higher if this transformation does not happen in the course of time. The promoters of this industry including various government organizations, OMCs, private enterprises, NGOs, etc., seem to be concentrating too much on increasing the area under the crop. But simultaneously, it is also vital to develop stable supply chains so that the feedstock produced is effectively marketed, processed and brought to the end-users. Even though some progress has been made in terms of area coverage, the processing infrastructure is far below than optimal. Moreover, most of the existing processing facilities are working under sub-optimal capacities. An area-wise critical assessment should precede investing in processing infrastructure so as to fully utilize the economies of scale in processing. Also, a demand pull for biodiesel is lacking due to which distribution channels are not well defined. Since cost-effectiveness of biodiesel also depends on the revenue from its by-products like oil cake and glycerin, simultaneous expansion of by-products market is also equally important.

5

Conclusions and Policy Implications

Extensive programmes on biofuels based on agricultural feedstocks can have considerable implications for the food and livelihood security of the people in a country. The recent debates over the rising food prices and the associated fallouts as a result of large-scale shift of area from food crops to biofuel feedstock crops have created concerns among the policymakers, scientists and common man in both developed and developing countries. It is mainly because, the market response of a shift against food crops at the global level may affect not only the agricultural sector but other sectors of economy also, irrespective of the level of participation of a country in biofuel production. Moreover, huge sums of outlays for subsidies on biofuels essentially means a shift of money away from the poor and vulnerable who end up spending more on food due to increased food prices, with little left for energy, even though cheaper.

In India, nearly 70 per cent of the population lives in the rural areas and depends on agricultural and related activities for livelihood. Moreover, in the rural India, around 33.8 per cent[18] people still belong to the below poverty line (BPL) economic status. Food security continues to be a priority for the Indian government in all its developmental efforts. Even though India is self-sufficient in terms of food production, almost 50 per cent of the children and practically the same number of women suffer from protein calorie malnutrition in the country as judged by anthropometric parameters. Therefore, any large- scale biofuel programme has to ensure that it does not compromise with the food and nutritional security of the nation. In an effort to expand the biofuel sector in the country, it should be ensured that the area under food crops should not be diverted to biofuel crops. However, India's current strategy of utilizing unirrigated, barren and wastelands for growing non-food biofuel crops would prove fruitful with multiple benefits like

[18] Planning Commission Poverty estimate based on head count ratio (HCR) for the year 2009-10.

greening of unused lands, generation of employment opportunities, greater people's participation and so on. In this regard, there is another point of view that diversion of forest and wasteland for cultivation of energy plantations may cause a conflict with pastoral livelihoods. Ambiguity in land rights is also considered a big issue in the development of wastelands for biofuels. Therefore, the facts regarding such arguments need to be verified before opting for a full-fledged expansion of biofuels in the country.

The promotion of biofuel development appears highly attractive for a developing country like India because of its potential of creating employment opportunities for the rural poor, offering opportunities for promoting local level entrepreneurships and enhancement of women empowerment. The availability of technologies for the decentralized production of biofuels offers opportunities for the development of local level entrepreneurships. Local institutions like JFM committees, SHGs and *Panchayats* can play a very important role in involving village communities in biofuel programmes. Locally-produced biofuels can provide fuel for irrigation pump-sets and for electricity generation, which will improve access to modern energy services to the rural population and help in improving productivity. The potential of engaging women in raising nurseries and in collection of TBOs could lead to their enhanced participation in the village economy.

Even though the central government is involved in the strategic decisions on biofuel policies, the actual implementation rests on the state governments. Presently, there seems to be a disconnect between the state policies and the priorities of the centre, especially with respect to tax and pricing policies, transfer of land title rights, etc. Similarly, in several aspects, divergence between the policies and approaches pursued by various state governments is apparent. The public private partnership with buy-back arrangements, and with need - based support from NGOs seem to work well in most of the states. However, the governments should take adequate actions to ensure fair prices to the farmers. With regards to land transfer to the farmers, the model of extending usufruct rights to the beneficiaries adopted by the Uttarakhand government may be replicated. The lack of coordination among various departments of the state governments is also hampering the biofuel development. For instance, in some states like Karnataka, a lack of coordination in the activities of Agriculture Department and Forest Department is evident. If the central government plans to extend biofuel programme to other states, it has to keep in mind the lessons learnt from the bitter experiences of *jatropha* programmes in Andhra Pradesh and Tamil Nadu. Therefore, it is important to ensure that the national and state policies on biofuels are comprehensive and are based on the pillars of economic viability, technological feasibility, environmental sustainability and market-friendliness. Such a policy should simultaneously ensure energy security and environmental sustainability without compromising food security of the nation.

Given the current crop yields, feedstock availability and conversion technology, the ethanol production in the country seems to be barely cost-effective. There is widespread concern over the long-term sustainability, economic viability and commercial feasibility of the ethanol programme in its present shape. The findings of the study reinforce that ethanol production focused over sugarcane molasses as a primary feedstock is neither convincingly economically viable nor sustainable with the available technologies. The country has to look for improved technology and better management practices to bring down ethanol costs. Lower plant capacity, use of batch process technology, inefficient by-product and effluent management practices (among other short comings) are considered as major technological constraints. Long-term technological targets like biotechnological applications to increase sugar content of crops, commercial use of membranes and microbes for ethanol production and other means should be devised. Even though direct conversion of sugarcane to ethanol yields higher recovery, this would not be a viable option when weighed against sugar requirement of the country. Moreover, it is obvious that expansion of area under sugarcane for the purpose of biofuel production will result in bringing down the area under other food crops, thereby threatening food security. On the whole, the results of the study strongly suggest that sugarcane based ethanol production is not at all sustainable in India. It is therefore, imperative to prioritize the various options available so that the efforts are not only directed towards making it sustainable and economically viable, but also pro-poor and resource-efficient. If promoted, sweet sorghum-based ethanol may prove a better option, which would be pro-poor in marginal and rain-fed areas and so is the case with tropical sugarbeet. Therefore, selection of the best feedstocks with long-term prospects should be one important course of action. But concurrent with this, efforts should also be made to improving the existing technology to achieve a higher level of efficiency, that is critical to its success. Both government policies and private entrepreneurial efforts, therefore, need to be fine-tuned and directed to this effect.

There are too many unknowns at this stage, particularly about the *jatropha*-based biodiesel programme. Still, farm studies suggest that *jatropha* is a profitable crop in the long-run, provided, government support in the form of input subsidies and technical and marketing assistance is made available during the initial few years. The farmers consider *jatropha* as a supplementary crop which can augment their income and employment to a certain extent but are also concerned about the uncertainty regarding its yield potential, long-term economic viability essentially linked with a sustained demand for seeds, undesirable externalities like loss of common grazing land, etc. On the seed processing front, biodiesel can compete with petro-diesel if the processing plants are operated at sufficient economies of scale. This can be realized by ensuring a stable supply of feedstock and consistent market demand of biodiesel and its by-products. Proper backward and forward integrations at each level of the supply chain are therefore crucial in making the biodiesel industry operate at economically viable scale. So far, the participation of corporate sector in developing the processing infrastructure and distribution channels has been feeble. Necessary steps have to be taken to bridge this gap. A centrally co-coordinated mechanism to supervise research, extension, development of processing and market infrastructure and various other assistance programmes should replace the existing piecemeal approach. Legal provisions to check a possible breach of *jatropha* area towards food crops is also worth considering, although this may only be feasible to enforce for larger commercial ventures, since land-use decisions among numerous smallholders can be difficult to monitor and regulate.

Scientific studies on the environmental sustainability of biofuels have been rather limited in India. However, at a time when the world is getting increasingly concerned about global warming, comprehensive studies on the following aspects are extremely important before further expanding the biofuel sector: crop-wise, location-specific impacts on primary energy consumption and emissions over complete production cycle; impacts of biofuel crops on biodiversity ; effects on land and water resources as a result of change in cropping pattern and cost-effectiveness of achieving emission reductions through biofuels.

In nutshell, even though India's biofuel programme sufficiently addresses the larger concerns of food security, rural livelihood security, gender empowerment, etc., there are several aspects which need further attention and concerted involvement. This study has highlighted several such un-tackled issues as economic viability and long-term sustainability of sugarcane-based ethanol programme, commercial feasibility of *jatropha*-based biodiesel, technological challenges constraining the development of second generation biofuels industry, loose ends in the national and state biofuel policies, etc. Therefore, the immediate challenge before the state is to bridge the existing gaps in the biofuel sector and to usher in a more consumer-friendly and market-oriented bio-energy revolution in the country which should be not only pro-poor but also environmentally sustainable.

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Annexure 1

Questionnaire 1: Estimation of Cost of Production of Ethanol in Uttar Pradesh

Date: ______________

1. Name of the Industry: ____

2. Address of the Industry:

Place: _________________District: _______________State: _____________

3. Whether the Industry is:

(a) Privately owned: ______________ (b) Government owned: _____________

4. Whether the Industry is:

(a) Stand alone distillery: _________ (b) Integrated with sugar production:______

5. Particulars of the plant:

Year of machinery installed	
Value of machinery installed (Rs)	
Revenue earned per year (Rs)	
Total labour force employed per annum (man days)	
Distillery capacity (litres/ year)	

6. What feedstock do you use for production?

(a) Molasses: _________________(b) Any others (name them):______________

7. What process do you use for conversion of molasses into ethanol?

____

8. Alcohol production details per year:

Total molasses consumed (litres)	
Alcohol produced (litres)	
No. of working days of the plant	
Capacity utilized (%)	

9. What chemicals do you use in distillation /fermentation?

____

10. Where do you buy/source molasses from?

____

11. Cost of production for processing one tonne of molasses (Rs):

Inputs	Quantity	Price (Rs/Unit)
Molasses cost		
Electricity/power costs		
Chemical costs		
1.		
2.		
Labour wages		
1. Managerial cost		
2. Administrative cost		
3. Casual labour cost		
Transportation costs		
Any others		
1.		
2.		

11(a) Do you use any other power source?

(a) Yes____________________(b) No____________________

If yes, list them and the cost:

Other source	Quantity used (per tonne of molasses produced)	Value (Rs)

12. What is the life of plant/machinery installed?

____

13 (a). What is the approx. value of building/land attached with plant?

____

13 (b). How much depreciation do you estimate for the plant and machinery per year (%)

____

14. Expenditure on repairs and maintenance of the plant in a year (Rs)________

15. How frequently do you replace the molecular sieve? How much does it cost?

____

16. Do you have taken any loan for setting up the plant / in course of production?

(a) Yes_______________________(b) No_____________________________

If yes, give the amount (Rs) _____________ rate of interest (%) __________

16 (a). Which year was the loan taken

____

16 (b). From where ____

16 (c). Has government provided any subsidy /incentive on loan(elaborate)

____

17. What byproducts are left after distillation/fermentation?

____

18. What do you do with the leftover byproducts?

(a) No use _______________(b) Use in productive activity_________________

18. (a). If use in productivity activity, list the activity/ies and how much do you earn from it

By-products	use	Quantity*	Price

*Note: Quantity of by-product per tonne of molasses used

19. For what uses and at what rate do you sell the produced alcohol?

Uses	Denote against app. Box (%)	Rate at factory gate (Rs/L)
Potable purposes		
Industrial use		
Biofuel		
Other uses		

20. Who are your major customers for ethanol?

Customer/Company and place	Quantity sold per annum	Rate at factory gate (Rs/L)
1.		
2.		
3.		

21. Has government provided any incentive on alcohol/ethanol production?

(a)Yes______________________________(b)No___________________________

If yes, please give details ____

22. Have you undertaken any Research and Development on bioethanol?

(a)Yes____________________________(b)No_____________________________

If yes, please give details____

23. How do you treat the distillery effluents?

____

24. What are the major constraints you are facing, associated with distillery business?

____

____

25. Any other relevant information______________________________________

Annexure 2

Questionnaire 2: Data Collection from *Jatropha* Farmers in Rajasthan, Uttarakhand and Chhattisgarh

Date: ____________

1. Name of the village : ________________________
2. Name of the respondent : ________________________
3. Age : ________________________
4. Educational Qualifications : ________________________
5. Type of house : ________________________
6. Size of family : Adults : --------------------Children : -------------------------
7. Land holding particulars (acres)

Type of land	Irrigated	Unirrigated	Total
Crop land			
Other land			

8. Farming system followed last year

1. Crop	Area in acres	Yield (kg/acre)	Income per annum (Rs)
a.			
b.			
c.			
d.			
2. Livestock	No.	Yield per annum (Milk/ Meat/Eggs/Wool)	Income per annum (Rs)
a.			
b.			
c.			

9. Source -wise income (Rs/annum)

Crop -------------- Livestock -------------

Jatropha cultivation-------------- Wage labour -------------

Employment -------------- Other income -------------

Total income --------------

10. *Jatropha* cultivation particulars

Land	Area (acres)	Year of plantation	Spacing (m x m)	No. of seedlings planted / acre	No. of surviving saplings (%)	Present seed yield/ acre
(i) Owned land						
(ii) Forest land/ degraded land						
(iii) Community land (on-lease/ contract by SHGs, NGOs, other govt. agencies)						
(iv) Contract farming with private companies						

11. If community land is used for *jatropha* cultivation, give details of the arrangements

____

____

12. Has community/JFM /SHG s been involved in the plantation in the village?

(a) Yes (b) No

If no, why ____

____

____

13. If you are involved in contract farming- Type of contract (govt/private)

Is there any buy- back arrangement? Yes / No

If yes, what are the clauses? _____________________________________

____

14. Did you or any member of your family get employment in the *jatropha* plantation on your own land / other land ? (a) Yes (b) No ----------------

If Yes

Number of members ----------------

Numbers of days worked ----------------

Wages received (Rs/day) ----------------

15. Has any person other than your family member been employed in your owned land ?

(a) Yes (b) No

If yes

Number of members -----------------

Number of days worked -----------------

Wages paid (Rs/ day) -----------------

16. Was the *jatropha* nursery raised in the village? (a) Yes (b) No

17. What was the source of seeds/seedlings for planting? Give details on variety/ hybrid.

____

____

18. Did you get any support from government for *Jatropha* cultivation?

(a) Subsidy on seedlings ______________________

(b) Subsidy on other inputs (fertilizers, manures and pesticides) __________

(c) Minimum support price (MSP) for seed ______________________

(d) Credit from bank ______________________

(e) Others ______________________

19. Do you feel that *Jatropha* plantation is beneficial? (a) Yes ___________ (b) No ___________

How?

____

____

____

20. Has *jatropha* plantation improved the soil conservation in the village?

Yes (b) No ______

If yes, please give a brief detail: ______________________________

If no, please give a brief detail: ______________________________

____

21. Has any cropland been substituted for *Jatropha*? If yes, please provide details.

____

22. Have you been practising any intercropping with *Jatropha*? If yes, please specify.

____

23. Do you feel that the plantations can be further improved? (a) Yes (b) No

If yes, please give your suggestions for better performance to enhance production and productivity ______________________________

____

24. Expenses on *Jatropha* cultivation

(a) Labour

S. No	Activities	Labor required (man hours/acre)			Daily wages	Cost incurred
		Ist year	IInd year	III rd year onwards	Rs/day	Rs
(i)	Raising of nursery					
(ii)	Digging of pits					
(iii)	Planting of seedlings					
(iv)	Watering					
(v)	Manuring and fertilizer application					
(vi)	Pruning					
(vii)	Replacement of casualties					
(viii)	Protection					
(ix)	Harvesting					
(x)	Any other					

(b) Other inputs (Usage/acre)

S. No.	Inputs	Quantity			Cost (Rs)		
		I year	II year	III year	I year	II year	III year
(i)	Saplings (Nos)						
(ii)	Manure – FYM (t)						
(iii)	Fertilizers (kg)						
	• Urea						
	• SSP						
	• MP						
(iv)	Pesticides (kg/ litres)						
(v)	Irrigation						
(vi)	Others						

(c) Irrigation

(i) No. of irrigations / year ________

(ii) Source of water

(a) Canal (b) Tank (c) Tube-well (d) Bore-well (e) Pond (f) others

25. Production/yield

Year	Main product (Seed)		By-product (specify)		Any other specify
	Qty (kg/acre)	Value (Rs)	Qty (kg/acre)	Value (Rs)	Value (Rs)
III					
IV					
V					

26. Has there been any shortfall in the actual yield from expected yield? If yes, give reasons.

(i) Pest
(ii) Diseases
(iii) Seed availability/quality
(iv) Availability of other inputs, specify
(v) Labour problem

27. What is the mode of harvesting practised ? --------------------------------------

28. What is the pod to seed ratio? --

29. In your knowledge, does the yield of Jatropha (kg/acre/ year) vary with and without management practices?

    (i) With one irrigation/year ____________________________________
    (ii) With two irrigations/year ____________________________________
    (iii) One irrigation +Manure/ fertilizer application ___________________
    (iv) Two irrigations + Manure / fertilizer application __________________
    (v) Without management ____________________________________

30. Where do you sell *Jatropha* seeds?

S. No.	Quantity sold (kg/year)	To whom?	Distance (km)	Price obtained (Rs/kg)
1.				
2.				
3.				

31. Mode of transport

    (i) Bullock cart (ii) Head load (iii) Truck (iv) Tractor (v) Others

32. What suggestions you have to improve marketing of the *jatropha* seed?

    ____

    ____

33. In your knowledge, is there any *jatropha* oil extracting plant? If yes, give details

    ____

Annexure 3

Questionnaire 3: Data Collection from *Jatropha* Processing Plant in Rajasthan and Chhattisgarh

Date: ____________

1. Name of the respondent : ______________________________
2. Name of the Oil Milling Unit : ______________________________
3. Year of establishment : ______________________________
4. Village/block/state : ______________________________
5. Capacity of the unit : ______________________________

   (Crushing capacity in tonnes/day)
6. Number of crushing days / annum: ____________________________
7. Capacity utilization of the plant (%) ____________________________
8. Method of oil extraction: (a) Oil expeller (b) Solvent extraction (c) Others
9. Source of *Jatropha* seeds: ________________ Price paid: _______
10. Input use particulars: (Usage / day) or (Usage / unit of output)
    (Specify clearly whether the end product is *jatropha* oil or biodiesel)

Sl. No.	Particulars	Quantity	Unit	Cost (Rupees)	Subsidy if any (Rupees)
1	*Jatropha* seeds				
2	Labour				
3	Chemicals				
4	Electricity				
5	Maintenance				
6	Interest on working capital				
7	Depreciation on machinery				
8	Others				

11. What is the processing cost (Rs /litre) ________________________
12. Total cost of biodiesel (Rs/litre) : ________________________
13. Recovery of Straight Vegetable Oil (SVO) : ______________________
    (litres/kg of seeds)

14. Recovery of biodiesel (litres/kg of seeds): ______________________

15. Output particulars:

Sl. No.	Particulars	Quantity	Unit
1	Straight Vegetable Oil		
2	Biodiesel		
3	Oil cake		
4	Glycerol		
5	Other by-products		
	a.		
	b.		

16. Production history:

Year	Quantity of biodiesel produced (Tonnes/annum)	Quantity sold (Tonnes/ annum)	Profit from the unit (Rs/annum)	Reasons, in case of loss
2006				
2007				
2008				
2009				

17. Where do you sell SVO/ biodiesel ?

Sl. No.	Product	To whom?	Distance to selling point (km)	Price obtained (Rs/kg)
1	SVO			
2	Biodiesel			
3	Oil cake			
4	Glycerol			
5	Other by-products			
6	a.			
7	b.			

18. Constraints faced while processing and marketing of biodiesel and its by-products

____

____

____

19. Any other information regarding *Jatropha* seed processing:

Annexure 4

Summary of State-level Policies

Particulars	Rajasthan	Chattisgargh	Uttarakhand	**Odisha**	**Karnataka**	**Andhra Pradesh**	**Tamil Nadu**
Targeted crops	*Jatropha*	*Jatropha, pongamia*	*Jatropha*	*Jatropha, pongamia*	*Jatropha, pongamia, simaruba,* neem	*Jatropha, pongamia, simaruba*	*Jatropha*
Main actors (at grass root)	SHGs, CDDs, p*anchayats,* private companies	JFMCs, local farms, private investors	*Van panchayats*, JFMCs, SHGs	*Pani panchayats*, SHGs			D1 Mohan, AGNI NET, AHIMSA
Government support provided	Subsidized seedlings, link with MGNRGS, 20 year lease of wasteland to companies	Free *jatropha* seedlings, subsidies, investment subsidies, tax and stamp duty exemptions	Gene bank for jatropha	Subsidy on seedlings, link to programmes (MGNREGS, SGSY, ITDA)	Biofuel park. Planned: -insurance coverage , tax concession	Provide R&D programme involving ICRISAT, ANGRAU, CRIDA	Subsidized loans, exemption on seed purchase tax, VAT on oil
Government procurement price	Rs 6/kg	Rs 6.50/kg *(jatropha)* Rs 6/kg (*pongamia)*	Rs 3.50/kg				Rs 5-10/kg (with buy-back)
Private price	Rs 7-10/kg						

Government agency involved	BFA (biofuel authority)	CBDA, Department of Rural Development, Forest Department.	FDC , UBB	OREDA, OFDC	BSBDB State Task Force on Biofuel	Biodiesel Board (planned) DPRD RSADD	Agricultural, forest and rural development departments
Key partnerships			FDC with JFM and *van panchayats*	Odisha Nature Care Council, OUAT, DRDA MITS-Rayagada			NWDRA, MGNREGS, CWP

Annexure 5

Sampling Design for Farm Survey on *Jatropha* Cultivation in Selected States

State	District	Block	Villages
Rajasthan	Sikar	Sikar	Rakaipura
			Piprali
			Shivrankabas
		Swai Madhopur	Lasadia
			Hathidea
			Hanumantpura
Chhattisgarh	Bilaspur	Kota	Basajall
			Kanchanpur
			Mazawani
		Marwahi	Danikundi
			Rumga
			Kotmi
Uttarakhand	Dehradun	Kalsi	Chapnu
			Dhodav
			Amraya
		Raipur	Bhopalpani
			Kallimitti
			Sodasaroli

Annexure 6

Socio-economic Profile of Sample *Jatropha* Farmers in the Selected States

Parameter	Rajasthan	Chhattisgarh	Uttarakhand
Average age of farmers (years)	46.3	42.6	33.2
Average household size (No.)	9.0	5.3	7.9
Literacy (%)	38.3	66.6	23.3
Total operational holding (ha)	1.60	1.56	0.80
Irrigated area (%)	60.0	48.7	0.0
Total annual income (Rs)	187261	91182	145588
Share of income (%) from			
Crops	23.7	52.9	9.1
Livestock	44.1	7.6	15.4
Jatropha	1.7	18.4	45.1
Non-farm	30.5	20.9	30.4

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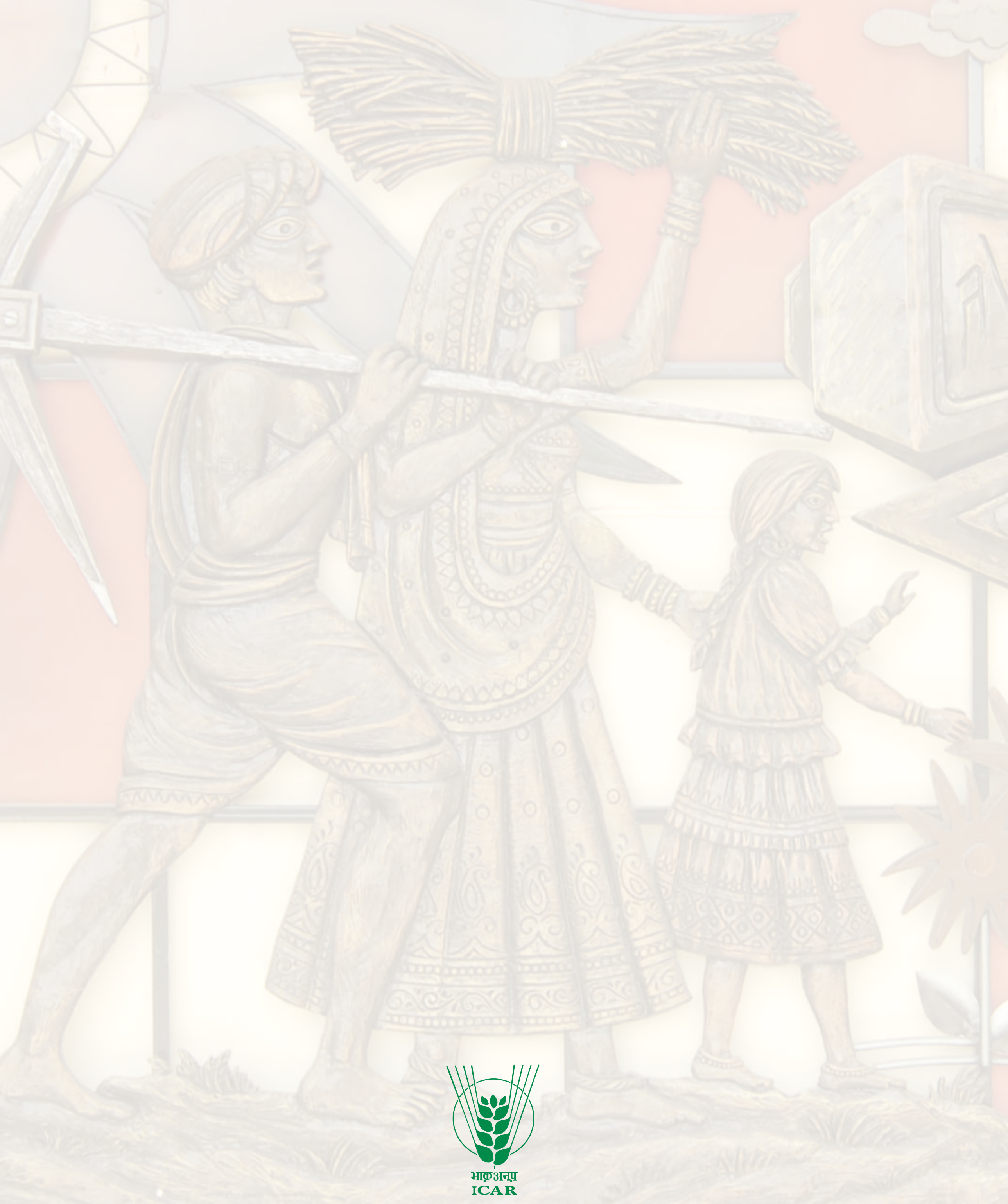

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