Chapter 19
Biofuel Policy in Indian Perspective: Socioeconomic Indicators and Sustainable Rural Development

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Abstract Biofuels are regarded as one of the most promising options to fulfill the higher energy requirement in future and simultaneously decarbonize the environment caused by excessive usage of fossil fuels. Technologies for the production of biomass based fuels particularly bioethanol and biodiesel are rapidly developing. However, successful commercialization of biofuels is still far due to high capital and operation expenditures and technical immaturities at large operations. Biofuel policies from major biofuels supporting nations might capitalize rural economic development and sustainable agricultural growth after strongly promoting biofuels. India has a biofuel policy, which foresees biofuels as potential candidates stimulating rural development by generating employment opportunities, together with environmental and economic benefits. The biofuel industrial sector has shown promising results and could serve as a potential source of substantial employment in near future. However, for the successful incorporation of biofuel policy, sustainable key indicators encompassing social and economic factors need to be evaluated properly in different scenarios. This chapter discusses the biofuel policies, key sustainable indicators, socioeconomic aspects of biofuels in Indian perspective.

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1 Introduction

The rapid pace of industrial developments and burgeoning urbanization have called for environmentally sustainable energy sources like clean transportation liquid and gaseous fuels, wind and solar energy, and others [1]. Liquid transportation fuels such as ethanol made from first generation sugars (first generation ethanol) and cellulosic sugars (sugars derived from cellulosic biomass), biodiesel, bio-hydrogen, solar and wind energy provide unique environmental, economic strategic benefits and can be considered a safe and the cleanest renewable energy alternative to fossil fuels [2]. Significant advances have been made in last 2 to 3 decades towards the development of renewable energy. However, there are still several technical challenges and economical barriers, which play a pivotal role in making the renewable energy program unsuccessful at commercial scale.

The attention on sustainable biofuel production worldwide is growing rapidly. The profitability of biofuel production is significantly linked with the policies of multiple sectors such as agriculture, food and feed processing, research and development, industry and commercial trade. The uncertainties in oil prices mandating the serious evaluation of opportunities for the production and consumption of biofuels. Furthermore, because of the price instability in crude oil and overdependency on import, governments are showing keen interest in development and promotion of biofuels even leveraging the subsidies to make biofuels commercially viable. The paramount challenges of today such as energy security, concerns about trade balances, greenhouse gas (GHG) emissions, rural livelihoods, and domestic farm commodities are important for pushing biofuels in near term [3]. Biofuels are also considered as a potential contributor in the socioeconomic development of rural areas, and could play a substantial role in alleviation of poverty via creation of new employment opportunities—impacting directly or indirectly the multiple millennium development goals [4–6]. For example, sugar and ethanol industry provides direct and indirect employment to an approximately 12% of the rural population in Brazil. Moreira [7] observed that sugarcane crop in Brazil employs one million workers at various levels. In fact, this industry is very important for rendering socioeconomic services to the rural community such as improvement in infrastructure, opening of schools, colleges, hospitals, among others in the sugarcane growing countries like Brazil, India, China and others.

Cultivation of bioenergy crops on unused or degraded forest land and wastelands is advantageous for the restoration of green land [7]. Biofuels sector may provide substantial employment in India, as the country is basically rich in agriculture. Biofuels sector covering second generation ethanol, biodiesel and associated products from biorefinery may create new employment opportunities. Sugarcane cultivation and sugarcane processing industries for sugar and ethanol production are the

primary agro-industrial sector in the country providing the livelihood of 50 million farmers and their dependants, (approximately 7.5% of the rural population). The sugar industry based employment further helped to save substantial foreign exchange, enabling India to strengthen infrastructural facilities with improvement in Gross Domestic Productivity (GDP). Moreover, it will reduce the dependency on the Organization of the Petroleum Exporting Countries (OPEC) countries and open a path for self-reliance in petroleum requirements.

Socioeconomic and environmental indicators (such as social wellness, energy and food security, external and internal trade, profitability, conservation of natural reserves) are the key elements to measure the sustainability of renewable energy options [8]. A balanced evaluation of sustainability indicators is imperative for commercial biofuel producers to make decisions about cultivation of biofuel crops, transportation, processing and conversion, and logistic of fuel blends concerning with the future or retrospective measures [8, 9]. For the long haul, it is very important to understand bioethanol production technologies in terms of their economic viability, environmental feasibility and empowering employment opportunities before implementing a fuel ethanol policy. The choice of the best technology for economically viable renewable fuel production directly depends on the overall economics (lowest cost), environmental benefits (lowest pollution), and least energy consumption (higher efficiencies). Correct measurement of economic viability with the right scale is essential to estimate renewable fuel production costs with precision. Critical analysis of key parameters such as (i) capital expenditures (CAPEX) constituting total capital investment, equity and leverage, interest rates, life cycle of plant machineries and their maintenances and (ii) operational expenditures (OPEX) embedding raw material, auxiliaries, residue management, (iii) fixed OPEX (operation, personnel, insurances, and servicing), and (iv) revenues from by-products are imperative for accurate economic analysis of renewable fuel production.

In this chapter, we review the biofuel implementation policies from major countries who are the strong advocates of biofuel usage and socioeconomic indicators in those countries. However, particular emphasis is given to renewable biofuel development, key sustainable and socioeconomic indicators in Indian context.

2 International Biofuel Policy Scenario

In the current scenario, when the world is developing not only industrially but also technologically, the concerns like global warming and depleting oil reserves have profound impact on setting up right biofuel policies in international arena. In fact, these problems act as driving force worldwide to explore the bio based materials which can be potentially used as feedstock for first and second generation biofuel production [10]. The interest in biofuel production got momentum due to unprecedented price hike in crude oil prices in 1970's, originally because of supply

restrictions imposed by the Organization of the Petroleum Exporting Countries (OPEC) cartel. High uncertainty in oil prices and negative environmental impact on environment using oil and gas catalyzed the search for alternatives, save or replace oil with economically feasible options such as biofuels. As per the analysis by British Petroleum (BP), energy consumption is expected to increase by 34% between 2015 and 2035. Oil and gas will hold the dominant place in supply energy. However, renewable energy in the form of liquid biofuels are also growing rapidly at 6.6% per year [11]. In 2015, world ethanol production has increased by 4.1% while biodiesel decreased by 4.9% [11].

With an increased environmental concern in the 1980's and 1990's, the use of biofuel gained further popularity, as a result of which biofuel production experienced sharp hike. High oil prices, benefits to agriculture and rural areas. and diversification of sources of energy might have also contributed to this hike. Along with all these issues, biofuel production also gained momentum by the concern of various government policies such as mandates, targets, and subsidies which cover the grounds of energy security and environmental considerations. Biofuel policies not only play a major role in the development of the energy sector but also provide thrust for innovation, research, and development. The key profitability indicators of biofuel production are primarily influenced by the policies of various sectors such as agriculture, research, industry, and trade. But this optimism with respect to biofuels took a pause when the concerns were raised by the global food crisis in 2007–2008 and the policy makers were in a dilemma on food security issues generated by first generation biofuel [12].

2.1 Global Biofuel Policies

This section deals with biofuel policies in four main biofuels markets, i.e., European Union, the USA, Brazil, and India. It is based primarily on the studies from the references from [13–16]. An overview of these government biofuel policies from major biofuel producing countries is shown in Table 19.1 [17].

2.1.1 Brazil

The only mature, integrated biofuel market in practice in the world is Brazil's cane-based ethanol market. The sugarcane -based ethanol/electricity cogeneration system became a competitive energy provider at USD$35 per barrel of crude oil prices [18]. Brazil has been the world leader in the mandated blending of biofuels for over 30 years, primarily under its National Alcohol Program (Portuguese: 'Programa Nacional do Álcool') or "*Pró-Álcool*" program [19].

It was a government intervention as a response to the petroleum shortage caused by the 1973 oil crisis that initial promotion of ethanol policies took place in Brazil

Table 19.1 Government biofuel policy of various countries

Features	Brazil	USA	EU	India
Mandatory/ Indicative targets	Mandatory blend of ethanol in Gasohol: 20–25%	– Mandatory use under the Renewable Fuels Standard (RFS). Rising to 28.1 billion liters in 2012 – Specific blend requirements being implemented at State level	Indicative blending target was 5.75% by 2010. Mandatory 10% blending target by 2020. Trend towards mandatory requirements in many member states	E5 blending program in some states recently extended E10 country wide by 2017
Tax credits/ excise duty reductions	Ethanol attract a lower rate of value added tax as against gasohol	If the cellulosic ethanol qualifies for alcohol fuel tax credits, the credit amount is reduced to $0.46 per gallon	Excise duty reductions allowed until 2010, then revision. Applied in many member states ranging from small reduction to complete removal. Trend towards declining tax support	Some tax exemptions provided in the Union Budget 2007
Import tariffs	No tariff	USD 0.14/l +2.5% of the value	Very high tariffs. EUR19.3 hl for un-denatured and EUR 10.2 for denatured ethanol	198.96% ad valorem (as a percentage of the customs value of the import) on CIF value (cost, insurance, and freight) for un-denatured and 59.08% ad valorem on CIF value for denatured
Feedstock supports	No	No specific support to biofuels but possible in 2007 Farm Bill	Yes With the CAP reform set-aside land can be used for energy crops production for which farmers receive a EUR45/ton premium (maximum 2 mln hectares)	Not directly Indirectly through minimum cane pricing

Source: Jolly [18] (modified from PowerPoint presentation) Government Biofuels Policy and Sugar Crops Policy Crops Outlook, International Sugar Organization

[19]. The *Pró-Álcool* program was started in 1975, as a strong support for ethanol demand and supply and to enhance the share of domestically produced fuel. The government initiated the bioethanol development of the industry through low-interest loans and enlisted a state-owned enterprise, Petrobras [20], to incorporate the product into gasoline. Through beneficial tax treatment, ethanol was available at a price that made it competitive with gasoline, and automobile manufacturers were persuaded to produce cars that were able to use the fuel at levels above traditional gasoline-powered vehicles. The 1990s observed the termination of this government supported *Pró-Álcool* program but market regulation and tax incentives of the program continued to be supported [20, 21]. Transition phase to a full liberalization took place between 1996 and 2000. Hebebrand and Kara [22] found that the blending mandate has been met by supporting policies, including local distribution requirements, subsidized credit for ethanol storage and tax preferences for vehicles. Currently, various incentives supporting demand is maintained without direct control on ethanol production and trade.

Currently, anhydrous ethanol blending is 18–25% for gasoline. This mandate is not relevant for pure hydrous ethanol which is sold at filling stations for use in flex fuel vehicles. Ethanol–gasoline blends up to 85% of anhydrous ethanol or on up to 100% hydrous ethanol fuel can successfully run these flex fuel vehicles. The mandatory blend of ethanol (18–25%) replaces the existing gasoline dependency (50%) and showcases the success of flex-fuel vehicles allowing ethanol fuel consumption in Brazil for transport. All gas stations are required to sell both gasohol (E25) and pure ethanol (E100). Figure 19.1 shows the competitiveness in

Fig. 19.1 A gasoline filling station from Piracicaba, São Paulo state of Brazil showing ethanol and gasoline price in August, 2016

ethanol (*etanol comum*), gasoline (gasoline *comum*) from one of gasoline station in Piracicaba-São Paulo state.

Biodiesel, though not a major product in Brazil, is blended with regular diesel (B5) at 5% rate [22]. In 2013, Brazil introduced biodiesel blending targets of 5%. The Brazilian federal and state governments grant tax reductions and exemptions to reach these obligations based on the agricultural producer's size and developmental level of region. Flex fuel vehicles get the privilege of lower taxes than those on petrol-powered vehicles, and similarly, ethanol is also bestowed with favorable tax treatment at the pump relative to petrol. The Common External Tariff of Mercosur (an economic and political agreement between Argentina, Brazil, Paraguay, and Uruguay) also protects Brazilian domestic biofuel production with ethanol duties of 20% and biodiesel duties of 14% which could be eliminated under the Doha and/or the EU-Mercosur trade negotiations with non-tariff barriers on Brazilian biofuels imports. Foreign investments in ethanol distillation plants and sugarcane production, especially from Europe and the USA, provide an important explanatory factor in the growth of the ethanol sector in Brazil. International investors are motivated by lower costs for ethanol production in Brazil which is an outcome of low prices of raw materials and the high technological level of the whole production process.

The drivers for biofuels vary according to local circumstances, specific domestic policies and initiatives. These issues drastically differ between countries. Brazil is the only country where production cost of ethanol and biodiesel is competitive with petroleum sources because of some inherent advantages like land availability, quality of land for sugarcane cultivation, rain, sunlight, soya production, and availability of knowledge and skilled professionals. Ethanol attracts a lower rate of value-added tax against gasohol. Over the medium term, the ethanol–sugar interface will remain centered in Brazil. In long term, some other countries will also start producing ethanol from sugar crops, which could be triggered by the correlation between sugar and energy prices. Brazil will continue to be the key player of the oil–ethanol–sugar interface. In the years of global sugar deficit, the world market can "buy-back" ethanol from Brazil.

2.1.2 USA

US Corn-based ethanol is an integrated and fully evolved system. The main drivers for increased biofuel demand in the USA are high energy prices and incentives provided by the Energy Policy Act of 2005 (EPACT05). The EPACT05 requires a minimum of 7.5 billion gallons (approximately 28.7 billion liters) of renewable fuels (ethanol and biodiesel) to be used in the nation's motor fuel.

The main issues those motivated the USA to form biofuel policies in 1970 were the concern for country's economy, environment and domestic farm commodities, which could be a prospective source of raw material for biofuel. Dependency on imported fossil fuels and increasing greenhouse gas emission were troubling country's economy and environment respectively [23]. Energy Tax Act of 1978

introduced the tax exemptions and subsidies for the blending of ethanol in gasoline. A subsidy of 4 cents per gallon of gasohol (E10), equivalent to 40 cents per gallon of pure ethanol, was introduced in the Energy Policy Act of 1978, through a partial exemption from the federal gasoline excise tax. Tyner [24] attributes the launch of the ethanol industry to this policy. The level of ethanol subsidy has varied over the years but presently stands at 45 cents per gallon, operated through a volumetric ethanol excise tax credit (VEETC). Biodiesel blenders receive a tax credit of $1.00 per gallon. Most of the states have tax exemptions and credits for use of ethanol along with the federal tax credit. The range of programs that exist for individual states is a testament to the strength of the lobbying effort of proponents of alternative fuels and vehicles that make use of those fuels. It also illustrates the difficulty of creating an effective notification mechanism for governmental assistance [25].

It took almost 2 decades for biodiesel to have subsidies implemented on it, on the platform of Conservation Reauthorization Act in 1998. Though the US fiscal incentives and mandates differed from state to state they were complemented by those at federal level. The US biofuel policies targeted specifically on mandates in volumetric terms as a part of the Renewable Fuel Standard (RFS) program, introduced under Energy Policy Act of 2005. This act framed the policies on mandates on consumption of biofuels. This act declared purchase objective of 4 billion gallons and 7.5 billion gallons of biofuel in 2006 and 2007 respectively. With the addition of biodiesel mandates, RFS program was expanded in The Energy Independence and Security Act (EISA) of 2007. According to this act, nine billion gallons of renewable fuel will be blended into transport fuel, and this horizon will expand to 36 billion gallons in 2022. To avoid the stress on first generation grain-based ethanol, the major share of this 36 billion gallons blending fuel will be covered by advanced second or higher generation biofuels (about 60%). The 2022 mandate for biodiesel is 1 billion gallons. Output-connected measures, support for input factors and consumption subsidies are the three principal instruments for current US biofuel policies. Largest direct subsidies are the tax credits whereas indirect subsidies are mandates and it does not provide direct support for price. Tariffs on ethanol are much higher as compared to that on biodiesel (24% in former and 1% in later in ad-valorem equivalent). This high tariff on ethanol limits its import from Brazil.

Ethanol producers significantly benefit from tax credits based on biofuel blended into fuels. Fuel consumers profit from the blender's tax credit as well—in the form of a lower fuel price—when the tax credit is combined with a binding blend or consumption mandate. Fuel consumers do not benefit, however, when the tax credit is the only binding policy. In this case, the consumer fuel price does not depend on the level of the tax credit, as shown by Gorter and Just [26]. The Volumetric Ethanol Excise Tax Credit and the Volumetric Biodiesel Excise Tax Credit provide the largest subsidies to biofuels while there are some smaller additional subsidies connected to biofuel outputs both on the state and federal levels.

2.1.3 European Union (EU)

Germany is the major producer of biodiesel in EU, where tax exemptions promote it. EU ethanol production capacity in 2006 was 2.1 billion liters which quadrupled about 8.5 billion liters in 2013. In EU, wheat, corn and sugar beet derivatives are main sources for bioethanol production. Germany, France, Hungary and the Czech Republic are the major countries in EU in 2015 and 2016 for bioethanol use. In 2016, consumption of biofuels in Germany is expected to increase because of the mandates in biofuels mandates to save GHG emissions.

In Europe, biodiesel production is growing more rapidly than ethanol production. World's largest biodiesel production occurs in EU. Biodiesel represents about 80% of the total transport biofuels market. Domestic consumption and competition from import are the two major driving forces for biodiesel production in EU. In 2014, biodiesel production increased by 11%, mainly in Germany, Spain, and the Benelux because of substantially lower imports and higher domestic consumption. In 2016, biodiesel production capacity in EU is expected to be 25.2 billion liters, with a 2% reduction from 2014.

The EU Biofuels Directive (BFD) has revised the total transportation fuel consumption profile and supporting biofuels and other renewable fuels in the EU. Almost 25% greenhouse gas (GHG) emissions are caused by the gasoline consumption. The goal was set to reduce the contribution in GHG emissions (based on energy content) to 5.75% and 10% by the end of 2010 and 2020 respectively. European Parliament and Member States [30] is reviewing these goals and will decide based on the 2020 results. Most the EU countries have not met the goals of 2010 to reduce 5.75% gas emissions [27].

It was need of the hour for EU to design its biofuel policy in order to fulfill its commitment to the Kyoto targets of Green House Gas (GHG) emission as concern for rising environmental issues from the EU population. It is not a single document, but a collection of a number of records which captures the EU biofuel policy. These documents are issued by different parts of the EU governance structure [28]. There are additional national aids for the production of "ethyl alcohol of agricultural origin" and occasional tenders for surplus crops to be converted to bioethanol. EU introduced Biofuel Directive 2003/30, which targeted at the use of 2% and 5.75% of biofuel in transport sector by 2005 and 2010 respectively at the EU level. It was only Germany and Sweden that exceeded 2005 target as they respectively used 3.86% and 2.11% of biofuel in total fuel consumption.

Germany's biggest drive on renewable energy by "Energiewende" (Energy Transition), with massive energy infrastructure investments is a big push in this direction and a good example for several countries. Among the EU nations, Germany is among the top users of renewable technologies in transport, heating, and power sector. In Germany, 12.2% of energy consumption, 20% of electricity consumption, 10.4% of heating, and 5.6% of transport consumption comes from renewable sources. Germany is also strongly advocating the use of biofuels in aviation sector also [29].

To execute the strategies on biofuel consumption EU Renewable Energy Directive (2009/29) established a "20-20-20 Policy" in 2009. Under this policy, various targets are set to be accomplished by the year 2020, which includes 20% reduction of total energy consumption in the EU-27, 20% reduction in Greenhouse gas emission and the share of renewable energy is set at 20% in the total EU energy consumption. Some agreements such as Cotonou Agreement, the Euro-Med Agreements and the Generalized System of Preferences Plus (GSP+) provides duty-free access to biofuel market of EU. These free access opportunities highly benefit some countries like Guatemala, South Africa and Zimbabwe.

Common Agricultural Policy (CAP) launched in 1992 supported the bioenergy drive in the EU. This policy brought energy-crop-premium of EUR 45/ha on a maximum of 2 million ha of set-aside land. This first pillar of reformed CAP proved itself unsupportive for bioenergy production. The second pillar of CAP comprising Rural Development Policy reinforced several measures that supported bioenergy development through the modulation instrument. Promotion of renewable energy production from perennial energy crops, agricultural and forest biomass was supported by enabling investment in infrastructure.

The EU trade policies have a big impact on domestic biofuel production, reduction in production incentives, and export opportunities for foreign biofuel producers. For biodiesel, the most-favored-nation duty is 6.5%. For un-denaturated ethanol and denaturated ethanol, the ethanol tariff barriers are on the higher level, EUR 19.2/hectoliter and EUR 10.2/hectoliter, respectively. Non-tariff barriers affect the trade of biodiesel considerably. For instance, even in the situation if tariffs for biodiesel are reduced, trade would have impact due to more restrictive non-tariff barriers in the form of quality and environmental standards [23]. Excise duty reduction was effective until 2010, followed by a gradual reduction to complete removal. Under the CAP reform, set-aside land can be used for energy crops production providing a premium of EUR 45/ha to the farmer.

EU passed a legislation in 2008 to use biofuels in transportation. Adopting the "Climate Change Package" in Directive for Renewable Energy (DRE) by EU in 2009, it was mandated that in EU, 10% of the transport energy should be from renewable sources by 2020 and 20% of the overall energy requirement should come from renewable sources [30].

2.1.4 India

According to International Energy Agency [31], global oil demand is projected to be increased by 60%, i.e., 7700 billion liters in 2030 with 68% increase in China and India alone. India is the fifth largest primary energy consumer and fourth largest petroleum consumer in the world. India spends over 45% of their export earnings for importing energy [32]. Biofuels have received considerable attention in India to curb the oil dependency [33].

Food security is primary concern for India to provide food to huge population while controlling the price elevation for food commodities and improving

agricultural productivity. Therefore, Indian government cannot allow the use of arable land, which is used for food and feedstock production, for the cultivation of biofuel crops. Food security is a grave concern for India as it is already one of the largest importers of vegetable oils in the world. Further, productivity of food grains like wheat, corn, rice and coarse cereals has been quite slow in recent years causing scarcity of food grains.

Water scarcity problems are also one of the major issues that India is already suffering from and this issue will only worsen as their food demand continues to grow with a rise in populations and incomes. India is exploring the possible implementation of a controversial multibillion-dollar project of inter-basin water transfers, to meet future demands [34].

The Government of India introduced Ethanol Blended Petrol Program (EBPP) in January 2003 with a vision of blending ethanol with petrol. National Policy on Biofuels formulated by the Ministry of New and Renewable Energy (MNRE) in 2009 recommended the blending at least 20% biofuels with diesel and petrol by 2017. Ethanol blending will increase the bioethanol requirement to 3.4 billion liters by 2020 [35]. As the present requirement of ethanol for the potable and chemical sector is fulfilled solely by molasses, to suffice the above need of blending there is a need to cultivate 20–23% more sugarcane (to generate molasses) than what is the present requirement of the sugar industry. However, to grow biofuel crops more land and water will be needed. To produce 736.5 million tons of sugarcane, to meet the molasses demand, an area of 10.5 million hectares will be required which seems impossible as it will deprive the production of food crops [36, 37]. Hence crop-based biofuels will exert pressure on water and land resources that already are heavily exploited or overexploited [34].

Considering pro-poor dimension as prime focus to harness the potential of biofuels sector in India, biofuel policy of India should address these concerns for the sustainable development. Subramanian et al. [38] stated that endeavor should be to produce ethanol from various feedstocks or organic matter we should not rely solely on molasses or food crops. India is blessed with abundant renewable energy resources. Provisions are being planned to encourage their use in every possible way. The Indian approach to biofuels, in particular, is somewhat different from the current international approaches which could lead to conflict with food security. It is based solely on non-food feedstocks to be raised on degraded or wastelands that are not suited to agriculture. The issue of fuel versus food security is not relevant in the Indian context. Policy support mechanisms to promote alternative feedstocks that will benefit all the stakeholders in the bioethanol supply chain in the long run while meeting the mandated requirements. In future too, it would be ensured that the next generation of technologies is based on non-food feedstocks.

In 1948, the Power Alcohol Act heralded India's recognition of blending petrol with ethanol. The main objective was to use ethanol from molasses to blend with petrol to reduce dependence on petrol imports, trim wastage of molasses and to bring down the price of sugar. *Jatropha curcas* was identified as the most suitable tree borne oilseed for biodiesel production by the National mission in April 2003 by the Government. Blending mandate was made optional in October 2004 because of

scarcity of ethanol during 2004–2005. Blending mandate was resumed in October 2006 in 20 States and 7 union territories in second phase of EBPP. In December 2009, the government introduced the comprehensive national policy on Biofuels after a series of policy changes. The final policy was framed by MNRE which called for at least 10% biofuels blending with diesel and petrol by 2017 [13].

2.1.5 Salient Features of National Policy on Biofuels, 2009

- The Policy aims at mainstreaming of biofuels and, therefore, envisions a central role for it in the energy and transportation sectors of the country in coming decades. The national indicative target of 5% blending by 2012, 10% by 2017, and 20% after 2017 has been recommended in the policy. The goal of the policy is to cater biofuel demand by ensuring the availability of a minimum level of biofuels in country.
- Nonedible oilseeds crop plantations on waste/degraded/marginal lands would be encouraged while the plantation on infertile irrigated lands would not be supported. In the context of the International perspectives and National imperatives, it is the endeavor of this policy to facilitate and bring about optimal development and utilization of indigenous biomass feedstocks for production of biofuels. The policy also envisages the development of the next generation of more efficient biofuel conversion technologies based on new feedstocks.
- A Minimum Support Price (MSP) to be announced for farmers producing nonedible oilseeds used to produce biodiesel. MSP with the provision of periodic revision for biodiesel oilseeds would be announced to provide a fair price to the growers. The Minimum Purchase Price (MPP) for the purchase of bioethanol by the oil marketing companies (OMCs) would be based on the actual prices of bioethanol production and import price of bioethanol. For biodiesel, the MPP should be linked to the prevailing retail diesel price.
- Financial incentives for new and second generation biofuels, includes a National Biofuel Fund. Bio-ethanol already enjoys concessional excise duty of 16%, and biodiesel is exempted from excise duty. No other central taxes and duties are proposed to be levied on biodiesel and bio-ethanol. Custom and excise duty concessions would be provided on plant and machinery for production of biodiesel or bio-ethanol, as well as for engines and that run on biofuels for transport, stationary and other applications, except those that are not manufactured indigenously.
- "Declared goods" would include biodiesel and bioethanol for ensuring unrestricted movement of biofuels within and outside the states. According to the policy, biodiesel would be exempted from taxes and duties. 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 are proposed to set up to address these issues in India. The Government is also considering the creation of a National Biofuel Fund for providing financial incentives like subsidies and

grants for new and second generation feedstocks cultivation; advanced technologies and conversion processes and production units. Hundred percent foreign equity would be allowed for biofuel technology and projects when the fuels produced are utilized domestically only in order to attract foreign direct investment (FDI). Vision, medium term goals, strategy, and approach to biofuel development are therefore set out by the policy. It also proposes a framework of technological, financial, and institutional interventions and enabling mechanisms.

- National Biofuel Coordination Committee under the Prime Minister for a broader policy perspective and implementation.
- Under this policy a Biofuel Steering Committee was set up under the Cabinet Secretary to oversee policy implementation. Several ministries are currently involved in the promotion, development and policy making for the biofuel sector.

  Overall policies for the development of biofuels and research and technology development for its production are made by the Ministry of New and Renewable Energy (MNRE), Government of India. Marketing of biofuels and developing and implementing a pricing and procurement policy is under the purview of Ministry of Petroleum and Natural Gas. The role of Ministry of Agriculture has promoted research and development for the production of biofuel feedstock crops. The Ministry of Science and Technology supports biotechnological research in biofuel crops, specifically in the area of biotechnology. A National Biofuel Coordination Committee (NBCC) headed by the Prime Minister was set up to provide high-level coordination of multiple departments and agencies and policy guidance/review on different aspects of biofuel development, promotion, and utilization. NBDB is developing a definite road map for use of biofuels in stipulated time frame to measure the policy issues.

The other main concern of this policy is the state independence. States are given the liberty to have biofuel policy and set targets of their own. This has resulted in a varied response in different states. States such as Karnataka and Rajasthan have taken off with a good start, and at the same time, there are states which are yet to make a landmark. "National Mission on Biodiesel" was launched in 2003 to address socioeconomic and environmental concerns. Two phases were proposed: Phase 1 by 2006–2007, demonstration project and by 2011–2012, Phase 2-self-sustaining expansion. Biodiesel purchase policy issued on 1st January, 2006 looks at biofuels as a potential tool to stimulate rural development by creation of employment opportunities to reap environmental and economic benefits. Biofuels promotion also outlines research and development, capacity building, sales and distribution of biofuels. India's current ethanol production allows blending of only ~3% in gasoline [39, 40]. Hence, the target set to make India energy independent turned out to be "highly unrealistic." A solution for reducing the dependence on foreign fuel in the perspective of changing global climate can be the promotion of advanced second and third generation biofuels.

3 Rural Development, Benefits to Indian Farmers and Daily Wagers

Biofuels are advantageous in that they would promote sustainable development, supplement conventional energy sources in catering to the transportation fuel demand and meeting the rural populations energy demands. Biofuels are bound to satiate the ever increasing energy needs in an ecofriendly manner and minimize the dependence on imports of fossil fuels and consequently providing a high degree of national energy security. Biofuel growth across the globe has been promulgated by energy security and environmental concerns, a wide range of market mechanisms, incentives and subsidies that have been put in place to facilitate growth. Figure 19.2 presents socioeconomic indicators of biofuels implicated for sustainability of biofuels for designing sustainable systems. Developing countries like India, apart from these considerations, also view biofuels as a potential means to stimulate rural development and create employment opportunities.

The Indian Government's vision 2020 states that cultivation of Jatropha on 10 million ha would create 7.5 million tons of fuel a year and consequently create year round jobs for people. But despite ambitious programs, targets are likely to be missed owing to the high costs of Jatropha-based fuel and red tape [41].

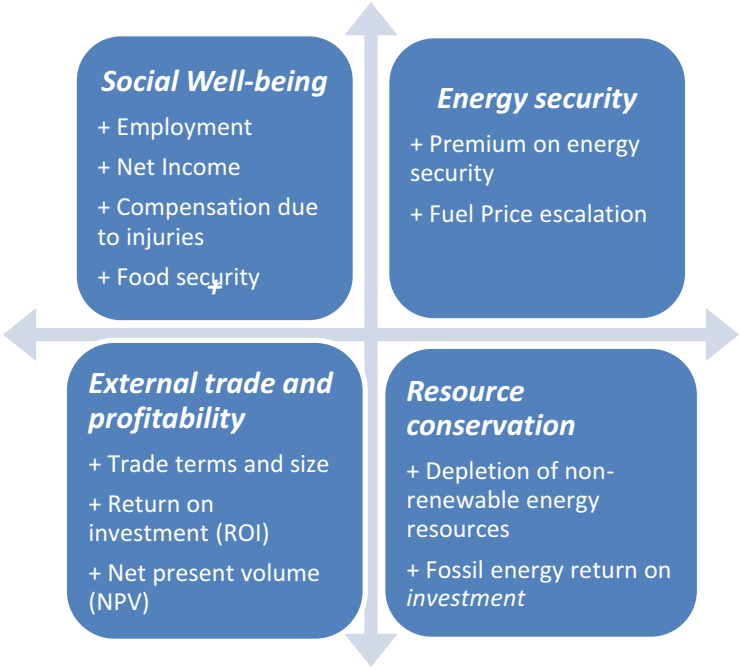

Fig. 19.2 Socioeconomic indicators of biofuels implicated for sustainability of biofuels for designing sustainable systems. These indicators have been modified for socioeconomic sustainability of bioenergy from algal biofuels systems [8]

Thus national policy of biofuels encourages biodiesel production from nonedible oilseeds, plants growing on waste, degraded, and marginal lands. This would encourage various agricultural producers to undertake plantations that provide feedstock for the biofuel industry. Over 400 species of trees are recognized in India that bear nonedible oil seeds. All of the recognized species would be evaluated for their exploitation as biofuel industry substrates by assessing their techno-economic viability. Plantations of trees bearing nonedible oilseeds will be taken up on government/community wasteland, degraded or fallow land in forest and non-forest areas. Minimum support price mechanism as proposed in the policy is also likely to promote contract farming on private wasteland. While plantations on agricultural lands would be discouraged, the corporates would be encouraged to undertake plantations by contract farming in consultation with panchayats where necessary. The employment created and provided in plantations of trees and shrubs of nonedible oilseeds would be covered under the National Rural Employment guarantee program (NREGP) [42] by Government of India. Seedlings from certified nurseries of recognized institutions identified by states would be distributed to the growers and cultivars.

The Ministry of Rural Development is specially promoting Jatropha plantations on wastelands and marginal land. Several programs nationwide have encouraged the planting of biofuel crops as well as procurement of seeds and cultivating. In this initiative, Ministry of Agriculture provides a subsidy through National Oilseeds and Vegetable Oils Development (NOVOD) Board to the farmers, ongovernmental organizations (NGOs), and individuals for the production of Tree Borne Oilseeds (TBOs) which include biofuel crops. Under this scheme, 30% credit linked subsidy is provided, with 50% term loan from the bank, and 20% beneficiary share in the form of land, labor, etc. The Ministry of Rural Development has provided financial aid of INR 490 million to 9 identified states in 2005–2006 and INR 495 million to 15 states in 2006–2007 for the plantation of *Jatropha*/*Pongamia* seedlings. Department of Rural Development of Chhattisgarh state is planting the TBOs under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). Plantation of biofuel crops is also in progress by the initiatives of several Joint Forest Management Committees (JFMCs) on forest land in the Chhattisgarh state [43]. The Chhattisgarh Biodiesel Development Authority (CBDA) provides *Jatropha* seedlings at highly subsidized rates for the promotion of planting in waste and forest lands. The authority is also encouraging the private investors to enter into contracts with local farmers for Jatropha cultivation.

Setting up of processing units by industry for bio-oil expelling/extraction and transesterification for the production of biodiesel is encouraged in the national biofuel policy. Gram/Intermediate Panchayats are also encouraged to create village level facilities for bio-oil extraction with corresponding sale to biodiesel processing units. Priority plantation of nonedible oil bearing plants, the setting up of oil expelling/extraction and processing units for production of biodiesel and creation of any new infrastructure for storage and distribution are declared as a priority sector for the purposes of lending by financial institutions and banks. National Bank of Agriculture and Rural Development (NABARD) would provide refinancing

towards loans to farmers for plantations. Indian Renewable Energy Development Agency (IREDA), Small Industries Development Bank of India (SIDBI), and other financing agencies as well as commercial banks would be actively involved in financing various activities under the entire biofuel value chain, at different levels.

National Biofuel Policy will also provide support for creation of awareness about biofuels and its potential and opportunities in upgrading the transportation infrastructure to support the rural economy. Various educational institutions will be encouraged to introduce suitable curricula to cater the trained manpower in all segments of the biofuel sector. Moreover, efforts will also be directed to enhance and expand the consultancy capabilities to fulfill requirements of biofuel sector. Intensive R&D work would be undertaken in the biofuel feedstock production based on sustainable biomass through nonedible oilseed bearing plantations on wastelands.

An instrumental factor of this policy includes providing a Minimum Support Price (MSP) for oilseeds and also having a thorough check on periodic revision which will ensure a fair price to the farmers and growers. The implementation of the MSP mechanism will be worked out carefully in consultation with concerned government agencies, states, and other stakeholders. For smooth working, Biofuel Steering Committee has to be set up in accordance with the National Biofuels Co-ordination Committee under this Policy. The farmers are getting the MSP of INR 6/Kg of *Jatropha* seeds from the governmental seed procurement agencies, while private companies buy at higher price of INR 7–10/Kg. The local farmers feel that decentralized value-addition options can provide a big change in their livelihood [44].

The Government of Odisha believes in revolving fund under the coordination of Odisha Renewable Energy Development Agency (OREDA) and Odisha Forest Development Corporation (OFDC) for providing subsidies of 50% to local communities like *Pani Panchayats* and self-help groups. and 33% directly to farmers above poverty line and 50% to farmers as groups. The policy also promotes the potential interlinkage between the biofuel program and various institutions like Swarna Jayanti Gram Swarozgar Yojana, MGNREGS, Integrated Tribal Developmental Agency, Compensatory Afforestation, Backward Regions Grant Fund schemes.

The government of Andhra Pradesh introduced a biodiesel policy in the year 2005 to facilitate investors and farmers to grow oil-bearing trees, mainly *Jatropha*, *Pongamia,* and *Simarouba*. Originally, the policy has proposed a three-way partnership program between government, industry, and farmers. In this program, the provision of buy-back arrangements for seeds and credit disbursement for farmers will be moved through industries. Plantations are promoted on forest lands under contract farming arrangements between private entrepreneurs and farmers [45].

Tamil Nadu government is also promoting the planting of *Jatropha* seedlings on wastelands. Primary agricultural cooperative banks in the state are enabling subsidized loans to farmers for *Jatropha* cultivation. According to the industrial policy of Tamil Nadu, 50% subsidy is given for *Jatropha* plantation and other biofuel crops and this subsidy is extended to the agro-processing industries. The state has

promoted the *Jatropha* cultivation for private companies like D1 Mohan Bio Oils Ltd., AGNI NET Biofuels Pvt. Ltd., AHIMSA, for the contract farming to farmers. Additionally, other services like training and extension support and provision of agricultural inputs are also being offered. These companies are offering buy-back arrangements with a certain market-linked price in the range of INR 5–10/kg for *Jatropha* seeds [46]. Biofuel policy of Tamil Nadu aims to bring a sustainable development and promotion for the cultivation, production and usage of biofuels crops and thus biofuels in state.

4 Socioeconomic Indicators and Governing Implementation Issues

With 4% of the world's energy consumption, India is the fifth largest consumer of energy after the USA, China, Russia, and Japan [47]. India consumes 4.4% energy resources (524.2 million tone oil equivalent (mtoe) of the world total (12,000 mtoe). In the world, primary commercial energy consumption in terms of using natural reserves (coal, oil and natural gas, nuclear and major hydro) has grown at 2.6% in the last 10 years. The growth rate of energy demand in India has grown approximately 6.8%; however, the supply has increased with a compounded annual growth rate (CAGR) of only 1% [48]. Therefore, India needs energy badly. Oil and gas constitutes about 45% share in the total energy consumption in India [48]. However, India is heavily dependent on crude oil imports, with petroleum crude accounting for about 34% of the total inward shipments (Ministry of Commerce and Industry, India). The imports have been ever-increasing, leaving the country with a growing balance of payment deficits. This necessitated India to work towards renewable and alternative fuels for energy security. Oil imports during April–February, 2014–2015, valued at US $130,848.36 million (Ministry of Commerce and Industry, India), were 12.24% lower than the oil imports in the corresponding period last year.

Though some alternatives like ocean water power, geothermal energy, wind energy, and solar energy are being explored, bioenergy is considered as a strong source of renewable energy in the coming years. The advantage of biomass is that the production of biomass for energy generation can contribute not only to climate change mitigation and energy security but also to rural development and employment generation [49].

The Government of India (GoI) approved the National Policy on Biofuels to encourage the use of renewable energy resources as alternate fuels to supplement transport fuels (gasoline and diesel for vehicles) and proposed a target of 10% biofuel blending (E10) by 2017. India produces conventional bioethanol from sugar molasses and production of advanced bio-ethanol is still in the research and development phase. However, taking the leads from R&D and process development unit, Praj Industries, Pune [50] is in the process of setting up the only one of its kind

demonstration facility for cellulosic ethanol production close to Mumbai. This facility is poised to use multiple feedstock (sugarcane bagasse, corn cobs, corn stover) for cellulosic ethanol production with low CAPEX and OPEX, with low wastes generation and reduced energy consumption. Recently, India Glycols Ltd., Kashipur has also successfully demonstrated the first cellulosic ethanol production process from lignocellulosic biomass with a capacity of 10 t/day. This facility has been built with the financial support from Department of Biotechnology (DBT), Ministry of Science and Technology and its Public Sector Undertaking—Biotechnology Industry Research Assistance Council (BIRAC). DBT believes that this technology which has lowest capital and operating costs may provide cellulosic ethanol at competitive price [51].

4.1 Elements of Energy Security

The Asia Pacific Energy Research Centre (APERC) defines energy security as "the ability of an economy to guarantee the availability of energy resource supply in a sustainable and timely manner with the energy price being at a level that will not adversely affect the performance of the economy" [52].

Several factors affect the security of energy supply of a nation—the availability of new and renewable energy resources, the accessibility of these sources regarding political and economic factors, the affordability of development and utilization of these resources, and the acceptability of these resources on environmental sustainability.

4.2 Availability of Resources

Oil contributes 40% of the world's primary energy demand [52]. India is the third largest oil consumer, utilizing 3.7 million barrels a day and accounted for about 4.2% of global oil consumption in 2013 [53]. The uncertainty of existing reserves and fluctuating crude oil prices have led to political instabilities in several countries. The reliance on foreign countries for oil and competition over energy sources are being considered as the major threats to a nation's energy security. Controlled pricing of petroleum products is yet another issue faced by the Indian oil sector [54]. Moreover, the world oil production is projected to peak in the next 10–15 years [52].

The national energy policy of India is planned by the Association of Southeast Asian Nations (ASEAN) which focuses on sustainable development [55]. India's energy policy integrates measures including the enhancement of energy efficiency and saving, exploration of domestic energy reserves, strategic reduction of energy poverty, and responding to the issues of climate change and sustainable development [56]. The development and utilization of nonconventional sources of energy is

getting utmost importance. Biomass, an abundant but underutilized resource, makes up 26% of India's energy resources [57]. Biomass can be used for combustion, gasification, pyrolysis, anaerobic digestion, fermentation and transesterification for the production of heat, electricity and as a substitute for petroleum for use as a transportation fuel [58]. To enhance biomass productivity and ensure biomass availability, biomass Research Centers (BRCs) have been set up in nine of the different agro climatic zones in India with an aim to develop packages of practices for fast growing, high yielding and short rotation fuel-wood tree crops suitable for degraded wastelands [59]. Development of processes for the production of the significant amount of biofuels without threatening food production needs special mention. The so-called "next generation biofuels" can tackle the "food-vs-fuel debate" and can open new avenues for promoting energy security. Several nations have implemented biofuel policies with the aim of securing future energy supplies [52]. Modernizing biomass technologies is a viable option. Also, concerted and continuous support from policy makers to have policies are a major challenge in the path towards a clean and green future.

4.3 Accessibility and Affordability of Resources

In order to attain the sustainable development goals of poverty alleviation, achieving food security, employment generation, and assumed access to affordable, reliable, sustainable, and modern energy for all, India has to significantly increase its energy availability [39, 60]. Besides availability, accessibility of resources economically is another challenge in ensuring a nation's energy supply. India, being the world's 7th largest economy [61], needs to maintain its annual growth rate at 8% to achieve its goal of energy security for sustainable development [56, 62]. However, the relatively higher energy prices result in a slow paced economic growth of the deficient energy economy of India [63]. Production and utilization of energy require both capital and labor. In order to make the inputs affordable, costs of nearly all goods and services in the economy need to be reduced, which can be affected only by lower energy prices. Indian transport sector is the largest and the fastest-growing consumer of petroleum, with 39% of petroleum products consumed [64]. The uncertainty of crude oil prices requires the transportation sector to explore new alternatives against the emerging economic challenges posed by a volatile oil market.

Renewable energy, which accounts for only ~1% of India's energy sources, is being promoted through public-private collaborations, as envisioned by the Ministry of New and Renewable Energy, GoI [57, 64]. The ministry provides budgetary support for research, development, and demonstration of renewable energy technologies, besides facilitating institutional finance and promoting private investment through fiscal incentives [64]. However, the high initial capital makes the renewable energy sources limited in access [52]. So, financial subsidies and policies are required to encourage investors. Also, transfer of technology from developed

economies to developing economies is recommended to increase developing economies' accessibility to renewable energy [52]. The SAHYOG Project (Strengthening Networking on Biomass Research and Bio-waste Conversion—Biotechnology for Europe India Integration) aims to actively link research activities implemented within EU research programs and related programs by Indian national institutions [65].

4.4 Acceptability of Resources

Biofuels are envisioned for their ability to contribute to energy security via supplementing transport fuels and combating climate change. However, ineffective transportation and production technologies may result in the requirement of more energy for production than the energy that can be supplied [39]. However, non-food crop based biofuels, with a smaller carbon footprint can significantly reduce dependence on fossil fuels [66]. Interestingly, reports show that production costs of biofuels have decreased over time, thereby lowering the efficiency costs of biofuel policies in the long run [66, 67]. An integrated biofuels strategy is required for meeting the imbalances between demand and supply in the energy sector. Cost competitiveness is a major challenge in this sector. To make renewable energy affordable in the future, investments in R&D and technology transfer are recommended [52]. Risks associated with all these factors and their impacts on national political, economic, social, and cultural security need to be considered to envisage a nation's energy security.

5 Biofuel Policy Implementation: Employment Creation and Rural Development

5.1 Employment Index in Indian Sugar, Ethanol, and Other Biofuel Industries

Sugar industry serves as a good example for how ethanol and biofuel industries could drive employment scene and impact rural society. The sugar industry is the second foremost agro-based rural industry that accounts for nearly 8% of industrial investment and provides employment for about 7.4% of the industrial working force by providing direct employment to 4 lakh people and about 35 lakh people are indirectly connected with this industry. A sugar mill of 1250 tons crushing capacity per day creates an employment potentiality of around 300–350 permanent workers and an equal number of seasonal workers. Besides this, for harvesting sugarcane, 5000 male and female workers are required to be engaged during the crushing

season. Likewise, around 100 tractors and 1000 bullock carts are given employment during the crushing season [68].

The Indian Sugarcane industry has more than 50 million farmers and their families' dependent on it for their livelihood. Direct and indirect employment generated out of the sugar industry caters to an estimated 12% of rural population. In addition to farmers, an estimated 0.5 million workers are directly employed as agricultural labor involved in cultivation and harvesting. Diversified ancillary activities and skills supporting local economy are also supported by the sugar industry [67].

Sugar mills have been working successfully, they have rendered considerable socioeconomic services to the rural community such as opening of schools, colleges, and hospitals. Besides, they provided numerous other facilities to the farmers in general. These activities and services are more evident in Maharashtra and Gujarat. The sugar mills have brought about a far reaching social, economic, and political transformation in the rural areas by providing various facilities like the modernization of agriculture, extension of the irrigation, employment, infrastructural facilities, education, health and recreation facilities, changing cropping pattern, and have promoted dairy and poultry activities. Thus, the sugar mills have acted as a catalyst for the socioeconomic development and these activities lead to the betterment of the economic conditions, not only of the farmers but also of landless laborers and other people in the areas.

5.2 Social Security

Employees feel insecure for many reasons such as inadequate wages, layoff and retrenchments, accidents and injuries in the course of employment, occupational hazards, sickness, old age, and total or partial disability. These factors cause anxiety and fear in their minds. Thus, the measures adopted to provide such protection to employees are known as social security measures. These measures protect workers and their families through various benefits such as compensation, maternity, sickness, and other benefits. Under Workmen's Compensation Act 1923, compensation is payable by the select sugar mills to workmen for all personal injuries caused to them by accident arising out of and in the course of his employment which disable him for more than 3 days. If the workman dies, the compensation is to be paid to his dependants. Under Employee State Insurance Act 1948, an insured person in the select sugar mills is entitled to receive benefits such as medical benefit, sickness benefit, maternity benefit, disablement benefit, dependants' benefit, funeral benefit, etc. The Employee Provident Funds and Miscellaneous Provisions Act, 1952 has made schemes for three types of benefits, viz., provident fund, family person and deposit linked insurance. Under the Payment of Gratuity Act, 1962 gratuity is payable to an employee of the sugar mill on the termination of his employment after he has rendered continuous service for not less than a 5 years. The completion of continuous service of 5 years is, however, not necessary where the termination of

the employment is due to death or disablement. The Maternity Benefits Act, 1961 applies to women in factories, mines and other establishments. In the select sugar mills, married women employees having not more than 2 living children are eligible for maternity leave as per the provisions of the Maternity Benefit Act, 1961. Employees Family Pension Scheme, 1971 seeks to provide some monetary relief to the family members of employees in the select sugar mills, who die in service, that is, before superannuation. In the event of an employee's death, his family gets a pension on a graded scale depending on the employee's last salary grade [68].

5.3 Human Resources Working in Public and Private Sector

The sugar industry provides employment to a large mass of population in India. Approximately, sugar industry provides livelihood of 6 million agricultural and 0.5 million skilled and semi-skilled industrial workers. Additionally, this sector generates significant employment in ancillary and allied activities. In India, sugarcane is grown approximately of 5-million-hectare land which is roughly 3% of the gross cultivable area in the country. In reality, sucrose-alcohol manufacturing sector is one of the largest agro-based industry in the country. The annual turnover of the sugarcane and sugar related segment is in the range of INR 80–85 thousand crores. A significant portion of this turnover around INR 55–60 thousand crores accrue to the sugarcane farmers of the various states in the country [67].

5.4 Number of Sugar and Alcohol Mills in India

Sugarcane cultivation and processing is major employment in ten states and union territories. Uttar Pradesh and Maharashtra are major sugarcane growing and processing states in India. However, other states like Andhra Pradesh, Karnataka, and Tamil Nadu are also contributing considerably in sugarcane production and processing. Sugarcane processing mills are widespread in Uttar Pradesh and Maharashtra. Sugarcane mills of every size, however, mostly do sugarcane processing of 2500–5000 TCD (ton cane/day). This capacity is expanding up to 10,000 TCD. Tropical and subtropical sugarcane producing belts in India has the capacity of 12–16 million ton white sugar production per season. In Gujrat and West Bengal, two standalone sugar refineries produce refined sugars (5000 MT capacity) from imported and indigenous raw sugar. These sugar processing units aims to augment the refined sugars production particularly when sugar production is low in country in order to ensure the sugar security in the country [68].

Globally, sugar market is passing through with the transformational changes and so Indian market is also being affected severely. For example, Brazil, the largest producer of sugarcane (~673 million ton) and thus producing largest sugar (~35 million ton) and second largest producer of ethanol (~30 billion liters), in

2014–2015 faced severe crisis. In last couple of years, more than 70 sugarcane processing units got bankrupted. Since 2010, around 50% drop in revenues was observed with cutting of thousands of jobs. However, the sucro-energy sector in Brazil is looking for regain due to heating up and competitiveness in fuel market along with the perspective of bigger profits in the various links which are encouraging to industries to invest in the renewal of sugarcane cultivation and eventually in sucro-alcohol processing units. In addition to the conventional, sucro-alcohol products, sugarcane sector is also looking for cellulosic ethanol production at commercial level from sugarcane bagasse and leaves. In Brazil, Granbio, Raizen and Abengoa has set up 80 million liters/year, 40 million liters/year and 65 million liters/year respectively [69]. Centro de Tecnologia Canaviera (CTC)-Piracicaba has also set up a demonstration facility of 100-ton bagasse processing/day (~3-million-liter ethanol per year) at Usina de São Manoel in São Paulo state.

India has in total 690 registered sugar mills and amongst them, 93 sugar mills are almost on the stage of permanent closure, as these sugar mills are not in production during the last five sugarcane processing seasons. However, some new projects are coming up in Maharashtra and Karnataka with the collaboration with existing sugar mills integrated with the planning for cogeneration and distillation facilities. Figures 19.3 and 19.4 show the total 642 sugar mills in India map. Maximum sugar and ethanol mills in India are privately owned and only few are governed by state governments. Privately owned sugar mills have higher cane crushing capacity than cooperative sugar mills. For instance, out of the operational per day cane crushing capacity of 22.24 Lac TCD, the private sector owns 13.74 Lac TCD while the cooperative sector owns 7.77 Lac TCD and remaining 0.73 Lac TCD is processed by public sector undertakings (29 sugar mills). Cooperative sugars are lagging in terms of fetching upcoming projects.

Indian Sugar Mills Association [67] provided the global and domestic data on sugarcane and its byproducts and domestic agricultural market intelligence with

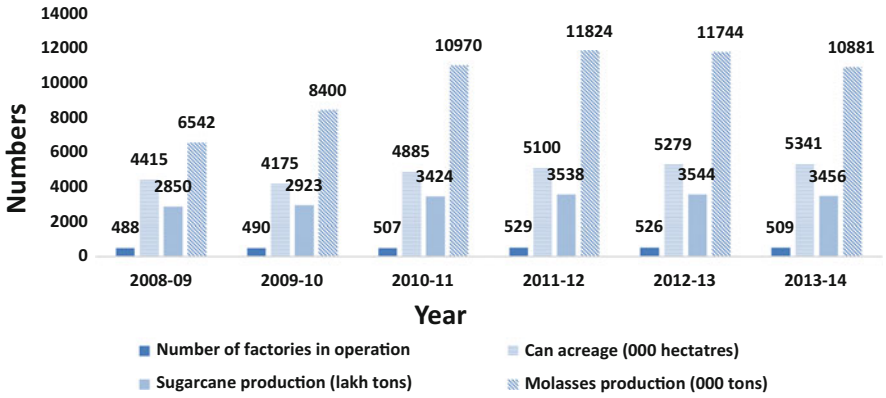

Fig. 19.3 Statistics of sugarcane production and sugarcane processing in India (Source: [67], http://www.indiansugar.com/SugarMap.aspx)

Fig. 19.4 Atlas of sugar mills in India (Source: [67], http://www.indiansugar.com/SugarMap.aspx)

Table 19.2 State wise of Indian ethanol production in 2015–2016 (adapted and modified from: [67], http://www.indiansugar.com/PDFS/List-ethanol_producers-2015-16.pdf)

Indian states	Number of Industries	Total installed capacity	
		KLPD (Kilo liter per day)	KLPA (Kilo liter per annum)
Bihar	6	335	90,450
Uttar Pradesh	35	2414	635,250
Punjab	1	60	16,200
Andhra Pradesh	11	500	144,900
Tamil Nadu	8	320	86,400
Maharashtra	68	3093	790,950
Gujarat	10	340	91,800
Karnataka	17	1225	294,300
Telangana	3	150	40,500
Other states (Uttarakhand + Sikkim + Haryana)	3	135	38,250
Grand total	162	8572	2,229,000

broad overview, key performance indicators and outlook analysis. ISMA report presents the current factual scenario of Indian sugarcane production, acreages, harvesting and crushing reports, sucrose-alcohol production, stock position and policies in states and the country [68] (Table 19.2).

6 Current Social Status and Improvement in Future

Development of villages have prominent role in holistic development of India as a large part of India's population lives in villages. Economic development in villages have a large gap than cities in India. Large rural population still do not have sustainable employment throughout the year because of poor infrastructure, non-connectivity with roads for transportation, inadequate electricity supply. Generally, for the daily routine activities and livelihood activities, rural population have to rely on polluting energy sources which have a harmful effect on the environment and their own socioeconomic development and health. Agricultural productivity has a profound impact in economic development in India. Agricultural products, byproducts and their management play a central role in renewable energy developent in India. Renewable energy development in rural areas can provide the following benefits:

- Facilitates access to drinking water;
- Allows lighting which increases security and enables the nighttime use of educational media and communication at school and home;
- Minimizes indoor pollution caused by the use of conventional fuels.

Rural population faces lack of access to affordable energy services. Biofuels produced from the raw materials grown locally in rural areas is likely to witness and aid in the alleviation of problems associated with poor standards of living. It is likely to mitigate the health issues faced by the rural population due to the traditional practices adopted to meet their regular fuel demands and also ensure energy security to the rural population.

The wasteland available in the country will be developed and utilized for cultivation of ethanol and biodiesel producing crops and will fulfill the basic requirement of fuel, fodder and food. By-products of the sugarcane ethanol industry contain valuable nutrients that have immense potential to be exploited as organic fertilizers.

The biofuels sector has the potential to serve as a source of substantial employment. Sugar industry in the major backbone of ethanol production industry in India. The sugar industry is the source of the livelihood of 50 million farmers and their dependants, comprising 7.5% of the rural population. Another half a million people are employed as skilled or semi-skilled laborers in sugarcane cultivation. This will reduce import burden to save substantial foreign exchange, enabling our country to strengthen infrastructural facilities with increased GDP. This will reduce the dependency on OPEC countries and open a path for self-reliance in petroleum requirements.

Sugar industry is likely to emerge as a significant contributor of the biofuel industry sector in catering to the energy needs of the country. This role would lead to a phenomenal transitional shift of the sugar mill into the energy complex. It is likely to meet around 20–25% of the total motor fuel requirements of the country in the near future. This would result in reduction of foreign exchange outgoing, attain

energy security along with satiating the traditional demands of chemical and potable alcohol based industry. All of this is likely to open up huge employment opportunities in the near future.

Today, Government of India through National Institute for Transforming India (NITI) Aayog is also trying to deploy methanol or wood alcohol as a promising source to curb carbon emissions while savings foreign exchange via reducing imports crude oil. Currently, India annually spends INR 4.5 lakh crore on purchasing crude petroleum. Chemistry of methanol is excellently support to be blended it with petrol while dimethyl ether can be a good and cleaner alternative to diesel [70].

6.1 SWOT Analysis

In general, SWOT matrix entails the strategic planning to evaluate the Strengths, Weaknesses, Opportunities, and Threats of any business venture. Here, we do the SWOT Analysis of biofuel production and its impact on socioeconomic status in Indian context (Fig. 19.5).

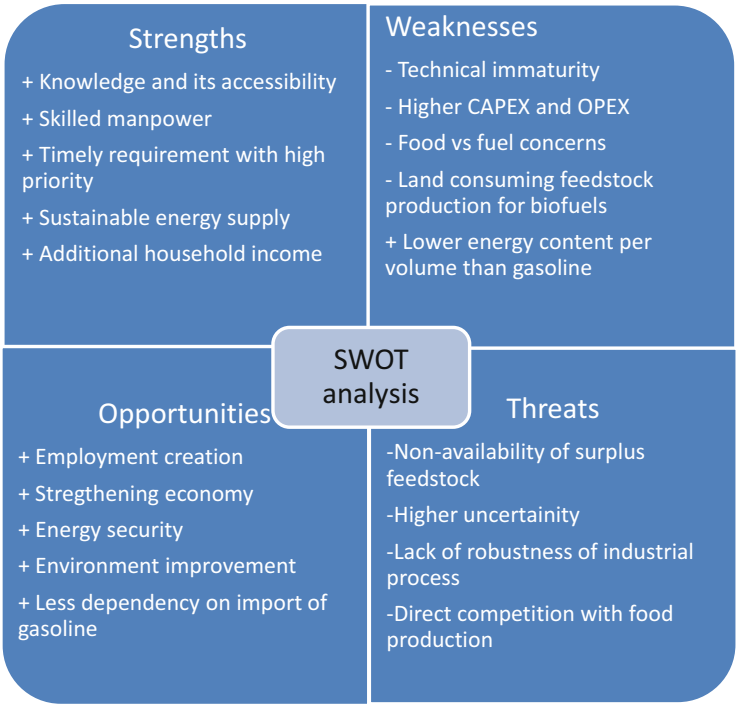

Fig. 19.5 SWOT analysis of biofuels in India

India ranks among one of the fastest growing markets for biofuels and renewable energy in the world. The Indian Government is making efforts to diversify the renewable energy portfolio, particularly in solar energy, small hydro and biomass. India has now over 8% annual economic growth rate. To maintain this growth rate, energy demand is projected to double by 2020. Therefore, India needs to harness all of the resources to get the power. Indian Government is making policies to bring foreign investment on renewables development in India. According to the HSBC estimate, India's "climate economy" will grow fivefold over the next decade, from $23 billion in 2009 to about $135 billion in 2020, roughly a 17% compound annual growth rate over that period [70]. In the last decade, private and public capital from national and international sources is flowing in through various national and international banks like International Finance Corp. and the Asian Development Bank.

7 Conclusions

Non-food crop-based biofuels, with a smaller carbon footprint, can significantly reduce dependence on fossil fuels. In the biofuel sector an integrated strategy is becoming imperative to meet the imbalances of demand and supply. Sugar industry is the emerging industry for catering to the ever increasing energy demands of the country by generation of electricity and bioethanol. These renewable energy sources hold the potential of converting the sugar mills into energy mills in due course of time. The biofuel sector has the potential to serve as a source of substantial employment. The national biofuel policy would also aid in the awareness creation of the role and importance of biofuels in the domestic market. It is also likely to promote wide dissemination of information pertaining to the potential of biofuel in upgrading the transportation infrastructure and supporting the rural economy. Substitution of petrol and diesel for transport with biofuels would witness accelerated development and promotion of cultivation of feedstock crops and production and use of biofuels. Increased utilization of biofuels in stationary and other applications and contribution to energy security, climate change mitigation, and creation of new employment opportunities is also likely to happen. By-products generated during the first and second generation biofuel production have the potential to bring down the cost of biofuels. However, constraints such as high operational expenditure (OPEX) and capital expenditure (CAPEX), and inefficient by-product and effluent management practices should be fixed in near term for sustainable development of biofuels.

This is imperative to set the biofuel policy by visualizing the situations in future using land-use pattern, alterations in crop mix, and the subsequent impact on food production. Biofuel crops could be even grown on fertile lands if oil prices keep skyrocketing. Certainly, promotion of biofuel development is highly judicious in India because of its potential of creating employment at each level, women empowerment, rural development, and augmenting entrepreneurships.

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