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37

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CENTRE FOR ECONOMIC AND SOCIAL STUDIES
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Foreword

The Centre for Economic and Social Studies (CESS) was established in 1980 to undertake research in the field of economic and social development in India. The Centre recognizes that a comprehensive study of economic and social development issues requires an interdisciplinary approach and tries to involve researchers from various disciplines. The Centre's focus has been on policy relevant research through empirical investigation with sound methodology. Being a Hyderabad based think tank, it has focused on, among other things, several distinctive features of the development process of Andhra Pradesh, though its sphere of research activities has expanded beyond the state, covering other states apart from issues at the nation level. In keeping with the interests of the faculty, CESS has developed expertise on themes such as economic growth and equity, rural development and poverty, agriculture and food security, irrigation and water management, public finance, demography, health, environment and other studies. It is important to recognize the need to reorient the priorities of research taking into account the contemporary and emerging problems. Social science research needs to respond to the challenges posed by the shifts in the development paradigms like economic reforms and globalization as well as emerging issues such as optimal use of environmental and natural resources, role of new technology and inclusive growth.

Dissemination of research findings to fellow researchers and policy thinkers is an important dimension of policy relevant research which directly or indirectly contributes to policy formulation and evaluation. CESS has published several books, journal articles, working papers and monographs over the years. The monographs are basically research studies and project reports done at the Centre. They provide an opportunity for CESS faculty, visiting scholars and students to disseminate their research findings in an elaborate form.

The present study on "Socio-Economic Analysis of Bio Fuel Production Cultivation: Baseline Survey in Madhya Pradesh" undertaken by my faculty colleagues brings forth important issues regarding alternate fuels from fodder crops to meet the challenge of reducing the carbon emissions (CO2). The need for such a study arises from the fact that depletion of fossil fuels at an alarming rate coupled with ever growing challenge due to anthropogenic factors induced climate change stress that has attracted increasing attention to blending bio-fuels world wide. According to the International Energy Agency (IEA), India will become the largest single source of global oil demand growth after 2020. Hence, India needs energy security along with environmental sustainability so that the eco-capacity of the conserved and environmental uncertainly arising from events such as climate change is mitigated. It is in this backdrop that the current study is undertaken in the state of Madhya Pradesh by my faculty colleagues that focused on knowing the existing scenario with reference to the proposed biofuel feed stocks Jowar (Sorghum) and Bajra (Pearl Millet) in the study area and understood the socio-economic aspects of sampled farmers. The study also assessed the economics of Jowar and Bajra crop cultivation of the sampled farmers and examined the ecological, social and livelihood significance of biofuel crops cultivation. It looked at the awareness levels of sampled farmers regarding biofuel cultivation and its impact of food and fodder security.

The State of Madhya Pradesh where the baseline stdy was undertaken is known for its vibrancy in agriculture sector. Even today, two-thirds of the total working population are engaged in agricultural pursuits as cultivators and agricultural labourers. Majority of the farmers are small and marginal farmers. Madhya Pradesh has the distinction of much diversified livestock resources. In MP, agriculture has been undergoing many changes over the past two to three decades and today it stands top in the country with respect to agricultural transformation growth. The increasing intervention of the state in agriculture, and the green and yellow revolutions, have prompted agricultural changes throughout the semiarid regions, especially in land ownership, cropping patterns, irrigation, credit and extension, agricultural productivity, prices and marketing etc,.

The research methodology adopted for the study is multi pronged in nature and the study used both qualitative and quantitative methods for understanding the farmers socio-economic and ecological aspects of jowar and bajra and the awareness about biofuels production through these crops. Personal interviews were conducted with a structured interview schedule. The study used an *ex post facto* research design and Focused Group Discussions (FGDs). The selected districts were Gwalior, Khargone, Dewas, Morena and Bhind. Districts hosting Sorghum and Pearl millet in large areas, were selected for the study. A total of ten villages were selected from five districts where the trials of high biomass feedstocks were conducted. Stratified proportionate random sampling was used covering 333 farmers belonging to different size classes in 10 villages.

The key findings of the study indicated that traditional jowar and high yielding varieties were doing well economically as compared to jowar hybrids. This means that the proposed high biomass varieties that are being encouraged as biofuel feed stocks should have comparative advantage over tradional and high yield varieties of jowar. Study found that more than ninty percent sampled households were not aware of biofuels. Majority of the respondents perceived that cultivation of Jowar and Bajra as biofuel feed stocks would not affect the food security but would definetly impact the fodder security of their livestock.

Inview of the importance of the above findings, there is need for larger debate on the use food crops in the production of alternate energy in place of current fossil fuel dependency. I am sure the study findings will be useful on the going food versus fuel debate and the scholars, civil society / NGOs, policy makers and scientific bodies will find them useful.

S. Galab

Director, CESS

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Acknowledgements

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Authors

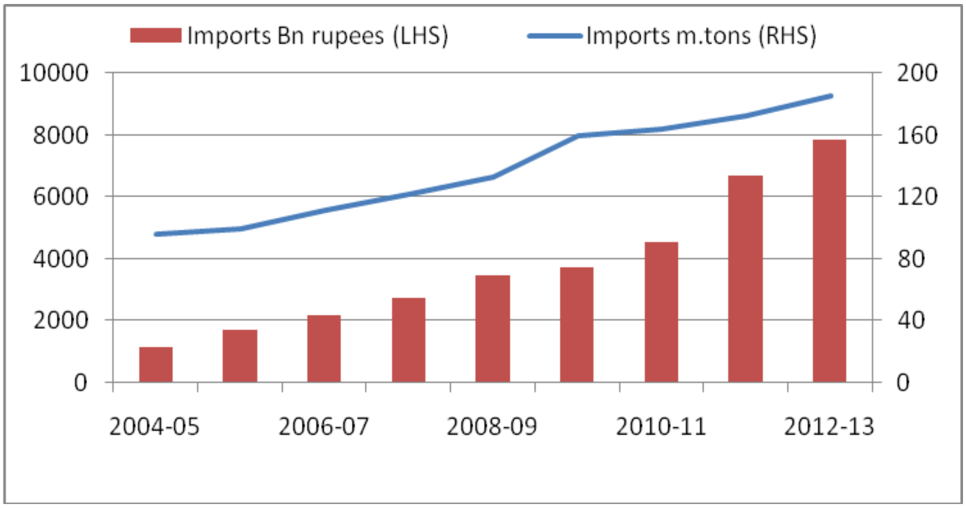
Chapter-1
Introduction

1.1. Introduction

Depletion of fossil fuels at an alarming rate coupled with ever-growing challenges due to anthropogenic induced climate change stress has attracted increasing attention to blending bio-fuels worldwide. India's energy demand is expected to grow at an annual rate of 4-5 times over the next couple of decades. According to the International Energy Agency, India will become the largest single source of global oil demand growth after 2020. Hence, India needs energy security along with environmental sustainability so that the eco-capacity of the conserved and environmental uncertainty arising from events such as climate change is mitigated. Of the total primary energy supplied to Indian economy in 2008, as much as 73.6 per cent was from commercial fuels while 26.4 per cent was from non-commercial fuels. Out of the total commercial energy, coal constitutes 57.1 per cent, followed by oil (31.65 per cent), natural gas (8 per cent) and carbon-free hydro, nuclear, and other new renewable resources (3.3 per cent) (IEA, 2013). Despite coal being the country's major resource endowment, the major source of India's energy insecurity is the heavy and growing dependence on oil imports. Off late, there have been sharp rising trends in crude oil prices coupled with volatility. India's transportation fuel requirements are unique as it consumes almost six to seven times more diesel fuel than gasoline, whereas in the rest of the world, almost all the other countries use more gasoline than diesel fuel. The National Policy on Biofuels (2009) has an ambitious target of mainstreaming the use of biofuels bioethanol and biodiesel by 20 per cent blending with Petrol and High Speed Diesel (HSD) by 2017. However the policy centers around the plantations and production of Jatropha on wastelands for the achievement of this target.

As discussed earlier, most of the energy requirements in India are currently satisfied by fossil fuels - coal, petroleum-based products, and natural gas. The energy security in the country is seriously affected because its domestic production can only bridge the requirement gap by 25-30 per cent, added to the burgeoning burden of imports. In 2012-13, the country imported 185.0 million tons of crude oil, which amounts to nearly 80 per cent of its domestic crude oil consumption, accounting to nearly 30 per cent of the country's total imports.

Figure 1.1: India's Crude Oil Imports

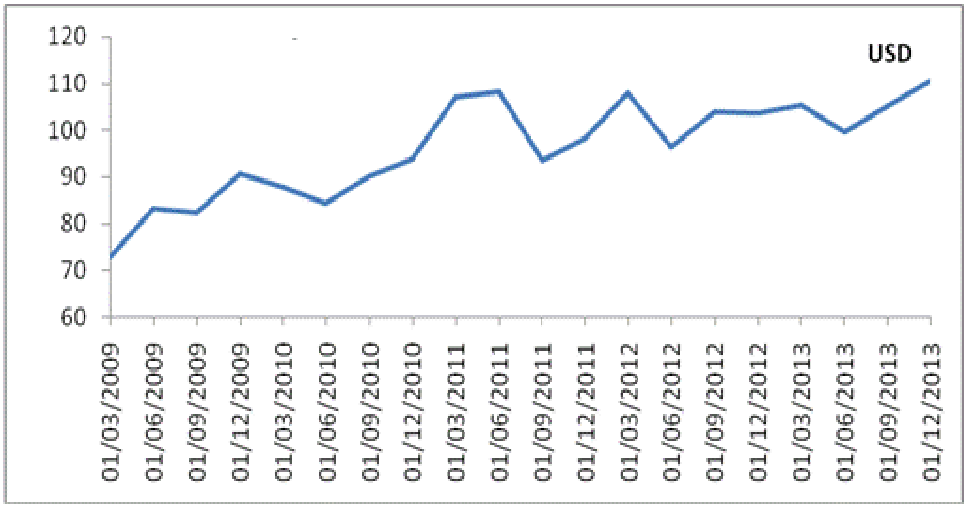


Source: IndiaStat.com

India's primary energy use is projected to expand massively to deliver a sustained GDP growth rate of 9 per cent through 2031-32, even after allowing for substantial reduction in energy intensity. In order to fuel this on a sustained basis, the growth of around 5.8 per cent per year in primary energy supply including gathered non-commercial fuels such as wood and dung would be required. Commercial energy supply would need to grow at about 6.8 per cent per annum, as it will replace non-commercial energy; but this too involves a reduction of around 20 per cent in energy use per unit of GDP over a period of 10 years. India is confronted with an energy crisis due to the depletion of resources and increased environmental problems. For example, diesel is the primary transport fuel of the country and comprises around 42 per cent of the total fuel market, majority of which comes through import market.

The rate at which the energy needs are growing demands either a greater reliance on imports (which is a strain on the depleting fiscal resources and foreign exchange) or a shift to alternative energy sources. With self-sufficiency levels in crude oil a distant dream, there is a growing interest/need in development and commercialization of a bouquet of alternative fuels. This necessitates the change of focus towards bio-fuels as a favorable alternative option. In addition to providing energy security and decreased dependence on oil imports, bio-fuels offer significant benefits such as reduced emission of pollutants and greenhouse gases. Most importantly, the industry has a potential to create avenues

Figure 1.2: Crude Oil Price (brent)

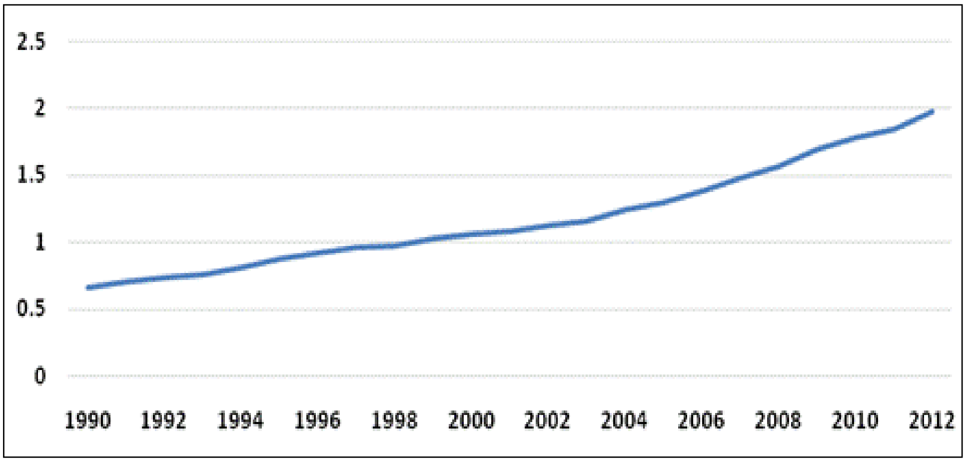


Source: eia.gov

to raise farmer incomes and restore degraded lands, while at the same time contributing to climate change mitigation.

Climate change is one of the most important problems faced around the world and most importantly in developing countries like India. According to the IPCC AR4, temperature has increased by 0.74°C in the last hundred years with the bulk of the warming occurring in the last 50 years. Temperatures have risen at a rate of approximately 0.13°C per decade from 1956 to 2005 (IPCC, 2007). Agriculture is the largest employer in the world and the most vulnerable to weather and climatic risks. In developing countries, around 70 per cent of the total population is dependent on agriculture. The majority of the total annual crop losses in the world agriculture is mainly due to direct weather impacts such as droughts, floods, untimely rain, frost, heat and cold waves, and severe storms (Folley, *et al.*, 2005, Hay, 2007). India accounts for only about 2.4 per cent of the world's geographical area and 4 per cent of its water resources, but has to support about 17 per cent of the world's human population, and 15 per cent of the livestock. Climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people. With an economy closely tied to its natural resource base and climate-sensitive sectors such as agriculture, water and forestry, India may face major threat because of the projected changes in climate (GOI, 2008). Hence, the country has reasons to be concerned about climate change as a vast population depends on climate-sensitive sectors such as agriculture, forestry and fishery for its livelihood in the country.

Fig 1.3 India's CO_2 Emissions 1990-2012 (Bn tonnes of CO2)



Source: Jos G.J. Olivier et al(2013), Trends in Global CO2 Emissions Report

According to the GOI report, climate change is likely to impact agricultural land use and production due to less availability of water for irrigation, higher frequency and intensity of inter- and intra-seasonal droughts and floods, low soil organic matter, soil erosion, less availability of energy, and coastal flooding, which could impact agricultural growth adversely (GOI, 2013). Crop specific simulation studies, though not conclusive due to inherent limitations, project a significant decrease in cereal production by the end of this century. Parts of Western Rajasthan, Southern Gujarat, Madhya Pradesh, Maharashtra, Northern Karnataka, Northern Andhra Pradesh, and Southern Bihar are likely to be more vulnerable in times of extreme events. The impact of climate change on crop productivity is significant and diverse as its impact differs even across different agro-climatic zones within a state, thus making implementation of mitigation strategies very difficult (Steven Raj P, 2014).

Hence, in order to tackle the twin problem of burdening energy security and mitigate effects of climate change on the Indian economy, the Union Cabinet of the Government of India approved the National Policy on Biofuels on December 24, 2009, which stresses on mainstreaming of bio-fuels in India to meet its ever-increasing energy requirements and to limit the carbon foot print of the country. The policy calls for setting up a National Biofuel Coordination Committee (NBCC) headed by the Prime Minister to provide over all coordination, effective end-to-end implementation, and monitoring of biofuel programme. Another Biofuel Steering Committee would be set up to tend to more regular and day-to-day coordination of the same which would be chaired by Cabinet Secretary (GOI, 2009). The National Biofuel Policy aims at ensuring that the next

Table 1.1: Impact of climate change on crop yields in different regions of India in PRECIS A1B scenario 2030*

Crop	Western Region	Coastal Region	North East Region
Rice (Irrigated)	Likely to be reduced by 4%, however irrigated rice in parts of southern Karnataka and northern-most districts of Kerala is likely to gain.	Decrease by 10 - 20%, in some coastal districts of Maharashtra; northern Andhra Pradesh and Orissa are projected to marginally increase by 5% with respect to the 1970s	Irrigated rice yields in this region may decline between 5-10%
Rice (Rain-fed)	All areas in the region are likely to lose yields by up to 10%.	Projected to increase up to 15% in many districts in the east coast and reduce by 20% in west coast	Decline 5-35% with respect to 1970s
Maize / Sorghum	Likely to impact yields by 50% depending on the region	Yield loss between 15% and 50% Rain-fed maize loss is up to 35%. AP to reduce by 10%	Projected to reduce by about 40%
Coconut	Likely to increase yields by 30%. South-west Karnataka, parts of Tamil Nadu, and parts of Maharashtra may show reduction in yields up to 24%.	Increase by 30% in west coast (provided water level is same). and by 10% in the east coast, esp. in north coastal districts of AP	
Livestock[1]	THI > 80 during September-April to reduce productivity	THI > 80 throughout the year	THI > 80 during months of April-October

Source: Indian network for climate change assessment, MOEF

* Assessed through a simulation model called InfoCrop

[1] The Temperature Humidity Index (THI), an index used to represent thermal stress due to combined effects of air temperature and humidity. THI > 80 severely impacts livestock health and productivity.

generation of technologies is based on non-food feed stocks so as to avoid conflicts with food security. 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 policy aims at bringing about accelerated development and promotion of the cultivation, production and the use of biofuels to increasingly substitute petrol and diesel for transport and be used in stationary and other applications, while contributing to energy security and climate change mitigation, apart from creating new employment opportunities and leading to environmentally sustainable development. The policy sets an indicative target of 20 per cent blending of biofuels, both for biodiesel and bio-ethanol by 2017; ethanol blending with gasoline was recorded as 2.9 per cent in 2013.

1.2 Biofuels

Sustainable development which ensures protection of resources and the environment for the future generations has become one of the important milestones to be achieved. According to the Burndtland Report (1987), sustainable development is a process which satisfies the need of the present without decreasing the ability of the future generations to supply their own demand. Given that environment is one of the most important pillars of sustainable development; the others being society and balanced treatment of the economy (Gathy, 2005), the focus shifts to renewable energy sources like biofuels, which aim to preserve the environment in a better way by substituting traditional fuels that are considered to be one of the biggest contributors to global environmental decay. Biofuel is a non-polluting, locally available, accessible and reliable fuel obtained from renewable sources. It is seen by many as a "clean" form of energy as the amount of CO2 released when it is burned is generally equivalent to the amount of CO2 captured during the growth of the crop that produced it. Since biofuels can be produced from diverse set of crops, each country can also adopt its local/regional/country-specific strategy in order to achieve comparative advantage. Liquid bio-fuels that are being considered world over fall into the following categories:

i) Alcohols - produced by fermentation of sugar and starchy crops, and quite recently from cellulosic biomass

ii) Plant seed oils - which comprise triglycerides of long chain saturated and un-saturated fatty acids. Bio-diesel is vegetable oils modified by trans-esterification to replace the glycerol molecules by methyl or ethyl groups

iii) Bio-crude and synthetic oils - are low molecular weight non-polar constituents of plant, which can be directly extracted from bio-mass and are generally a complex mix of lipids, triglycerides, waxes, terpenoids, polysterol, and other modified iso-perenoids that can be catalytically upgraded for use as liquid fuels.

Globally these different liquid fuels can be obtained from four different categories of biomass sources:

a) Plantations especially raised for producing energy or energy and food
b) Agricultural residues and wastes including manure, straw, bagasse and forest wastes
c) Uncultivated biomass such as weeds
d) Organic urban or industrial wastes

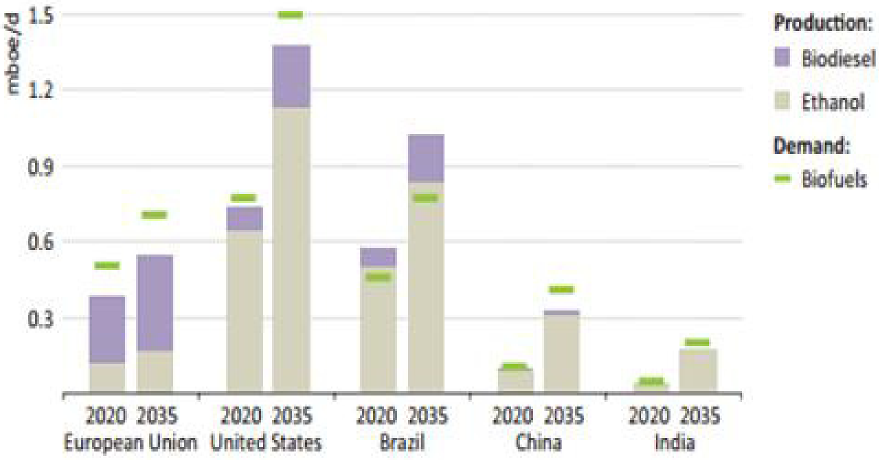
Table 1.2: Biofuels classification

First Generation Biofuels (from grains, seeds, sugars)	**First Generation Biofuels** (from grains, seeds, sugars)
Petroleum - gasoline substitutes - Ethanol or butanol by fermentation of starches (corn, wheat, potato) or sugars (sugar-beets, sugarcane)	Biochemically produced petroleum-gasoline substitutes - Ethanol or butanol by enzymatic hydrolysis
Petroleum diesel substitutes - Biodiesel by trans-esterification of plant oils, also called fatty acid methyl ester (FAME) and fatty acid ethyl ester (FAEE) - From rapeseed (RME), Soybeans (SME), sunflower, coconut, palm, jatropha, recycled cooking oil, and animal fats	Thermo-chemically produced petroleum-gasoline substitutes -Methanol - Fischer-Tropsch gasoline - Mixed alcohols
Pure plant oils (straight vegetable oil)	Thermo-chemically produced petroleum-diesel substitutes -Fischer-Tropsch diesel - Dimethyl ether (also a propane substitute) - Green diesel

Source: UNCTAD, 2008

Consumption of biofuels is projected to rise from 1.3 million barrels of oil equivalent per day (mboe/d) in 2011 to 2.1 mboe/d in 2020, and 4.1 mboe/d in 2035 (see fig.1.4). By 2035, biofuels are expected to meet 8% of the total road-transport fuel demand, up from 3% today. Ethanol remains the dominant biofuel, making up about three-quarters of global biofuels use throughout the period. Consumption of biodiesel in road transport more than triples over the outlook period to 1.1 mboe/d in 2035. Combined United States, Brazil, the European Union, China, and India account for about 90% of world biofuels demand throughout the outlook period, with government policies driving the expansion in these regions. In addition to the use of biofuels in road transport, its use in aviation begins to make inroads over the projection period (IEA 2013).

Figure 1.4: Biofuels demand and production in selected regions



Source: World Energy Outlook, 2013

1.2.1 Advantages

Added to its uniqueness as an environmentally friendly fuel compared to either gasoline or petroleum diesel, biofuel is also recognized due to its portability, ready availability, renewability, higher combustion efficiency, lower sulfur and aromatic content, and higher biodegradability (Ma F 1999; Konthe *et al.*, 2006). Bio-diesel has higher flash point temperature (>1000C), higher octane number and lower aromatics than that of conventional fuels. Added to this, biodiesel can be used in any diesel engine without any modification. Blends up to 20 per cent biodiesel mixed with petroleum diesel fuels can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment.

The clamor for shift to biofuel driven energy, especially in the transportation sector is gathering ground off late, more in developing countries like India, given its potential to reduce the dependency on imported fuel and thus reducing the burden on the exchequer. Moreover given that biodiesel can be manufactured from domestically cultivated crops would also contribute to better farm level incomes and also increased employment generation both at the field and factory level.

Table 1.3: Technical Properties of Biodiesel

Common name	Biodiesel
Common chemical name	Fatty acid ethyl ester
Chemical formula range	C14-C24 methyl esters or C15-25H28-48O2
Kinematic viscosity range (mm2/s, at 313 K)	3.3-5.2
Density range (kg/m3, at 288 K)	860-894
Boiling point range (K)	>475
Flash point range (K)	420-450
Distillation range (K)	470-600
Vapor pressure (mm Hg, at 295 K)	<5
Solubility in water	Insoluble in water
Physical appearance	Light to dark yellow, clear liquid
Odor	Light musty/soapy odor
Biodegradability	More biodegradable than petroleum diesel
Reactivity	Stable, but avoid strong oxidizing agents

Source: Demirbas, 2009

1.2.2 Disadvantages

Despite their appeal as an alternative to fossil fuels, biofuels are also subject of considerable controversy. The major disadvantages of biodiesel are its higher viscosity, lower energy content, higher cloud point and pour point, higher nitrogen oxide (NO_x) emissions, lower engine speed and power, injector choking, engine compatibility and high price. The specific fuel consumption values of biodiesel are greater than those of commercial diesel fuel, while the effective efficiency and effective pressure values of commercial diesel fuels are greater than those of biodiesel. Biofuel production is not considered truly as carbon-neutral because the stages of production needs non-renewable energy while transporting and processing.

The primary concern is that the substitution of agricultural crops to produce biofuels may be inherently unsustainable (Peer *et al.*, 2008) as crops require land and water to grow and this would inadvertently in the long run result in the shift from food to non-food/fuel crops given higher incentives. Crops of any nature in industrialized agriculture require synthetic inputs such as fertilizers and pesticides, both of which are produced and transported using fossil fuel energy. This fact adds to the overall energy required to produce crops that provide energy and raises questions about whether the finished product provides more energy than is spent to produce it (Giampietro *et al.*, 1997). Another issue of concern is the impact on food security in the context of diversion of land to biofuel crops. It is interesting to note that the soaring food inflation during 2002-2008 is attributed to shift of food commodities to biofuels. Though increase in internationally traded food prices during 2002-2008 is attributed to a confluence of factors, it is chiefly attributed to increase in biofuel production from grains and oilseeds in the US and EU. The IMF estimated that the increased demand for biofuels accounted for nearly 70 and 40 per cent of the increase in maize and soya bean prices respectively (Lipsky, 2008). Land use changes in wheat exporting countries in response to increased plantings of oilseeds for biodiesel production and limited expansion of wheat production. Impact of food prices on developing countries like India is much pronounced given that they spend nearly half their household income on food (Donald Mitchell 2008).

Table 1.4: Biodiesel emissions compared to conventional diesel

Emissions regulated emissions	**B100 (100 per cent biodiesel)**	**B20 (20 per cent biodiesel)**
Total unburned Hydrocarbons	-93 per cent	-30 per cent
Carbon Monoxide	-50 per cent	-20 per cent
Particulate Matter	-30 per cent	-22 per cent
NOx	13 percent	2 per cent
Non-Regulated Emissions		
Polycyclic Aromatic Hydrocarbons (PAH)	-80 per cent	-13 per cent
NPAH (Nitrated PAH)	-90 per cent	-50 per cent
Life Cycle Emissions		
Carbon Dioxide (LCA)	-80 per cent	
Sulfur Dioxide (LCA)	-100 per cent	

Source: GOI, 2003

There is also considerable debate on whether the end fuel product will truly be better for the environment than fossil fuels when subjected to a Life Cycle Analysis (Heintzman and Solomon, 2009; Puppán, 2003). LCA is defined by the International Standards Organization (ISO) as "a compilation and evaluation of inputs, outputs and potential environmental impacts of a products system throughout its life cycle" (Guinée *et al.*, 2001).

Experiences worldwide suggest that the conventional fuels can be successfully substituted with biofuels. There are many successful experiences the world over from Canada, USA in North America; Brazil, Argentina and Columbia in South America; France, Germany and the European Union, India, China, Indonesia, Malaysia and Thailand in Asia, and Australia. Over the last decade that is between the years 2000 and 2009 biofuel production has increased dramatically from 16.9 to 72.0 billion liters, while biodiesel grew from 0.8 to 14.7 billion liters. The United States remains the largest biofuels market, spurred on by the Renewable Fuel Standard (RFS) through 2022 and assumed continuation of support thereafter, with consumption increasing from around 0.7 mboe/d to 1.5 mboe/d in 2035, by which time biofuels meet 15% of road-transport energy needs. Driven by blending mandates and strong competition between ethanol and gasoline, Brazil remains the second-largest market and continues to have a larger share of biofuels in its transport fuel consumption than any other country.

In 2035, biofuels meet 30% of the Brazilian road-transport fuel demand up from 19% today. Supported by the Renewable Energy Directive and continued policy support, use of biofuels in the European Union more than triples over the period to 0.7 mboe/d in 2035, representing 15% of road-transport energy consumption. In China, government plans for expansion lead to demand for biofuels reaching 0.4mboe/d in 2035, many times the current level. India established an ambitious National Mission policy on biofuels in 2009, but the infancy of the ethanol industry and difficulty in meeting current targets constrains future demand growth in the projections (IEA, 2013).

Of all the biofuel experiences, sugarcane-based ethanol being used in Brazil has been regarded as the most successful one as all gasoline sold in Brazil is a blend of 18 to 25 per cent ethanol in Brazil. The Brazilian national ethanol program Proalcool, was launched in 1975. After the second oil crisis in 1979, Brazil launched to shift to cars powered by entire hydrous ethanol. This was very successful as by 1985, as much as 95 per cent of the light vehicles produced in Brazil were built to use hydrous ethanol. In 2003, flex fuel vehicles were launched and currently account for 90 per cent of the new sales constituting the high point of Brazilian ethanol success story in the present decade. Brazil ethanol program is more consolidated because:

a) gasoline contains 25 per cent of ethanol,

b) ethanol is available in all gas stations, and

c) 50 per cent of the car fleet and 90 per cent of new car sales are of flex fuel.

This was all possible due to the strong sugarcane sector that is already established in the country. Brazil produced 717 million tons of sugarcane, which yielded 36.1 million tons of sugar and 27 billion liters of ethanol. Most of the ethanol produced is absorbed in the domestic market where it is sold as either ethanol fuel or blended with gasoline.

Table 1.5: Biofuel consumption in road transport (bioethanol and biodiesel), 2005-2012 (in TJ)

	2005	2006	2007	2008	2009	2010	2011	2012
USA	337,941	473,793	601,146	819,755	928,090	1,012,973	1,068,621	1,070,660
EU27	130,415	230,762	283,830	397,878	495,048	554,991	580,531	598,371
Brazil	291,533	270,201	373,039	502,514	550,826	588,900	521,186	517,495
China	0	42,200	39,056	49,188	51,742	50,696	63,217	63,217
India	4,556	5,038	5,601	6,191	6,861	7,611	11,736	11,736
Global	777,605	1,039,354	1,354,706	1,855,104	2,143,083	2,377,504	2,482,683	2,498,870

Source: Trends in Global CO2 Emissions: 2013

1.3 Biofuels in India

The two prominent biofuels in India are bio-ethanol (or simply ethanol) and biodiesel made from biomass containing sugar like molasses and vegetable oil like non-edible jatropha oil respectively. The policy document on biofuels defines biomass as "biodegradable fraction of products, wastes and residues from agriculture, forestry and related industries as well as the biodegradable fraction of industrial and municipal wastes" (GOI, 2009).

Ethanol is manufactured in India by fermentation of molasses, which is a by-product of the sugar industry. India is the fourth largest producer of ethanol in the world after Brazil, the United States and China, with distillation capacity of 2,900 million liters per year. The Government of India made 5 per cent blending of ethanol with petrol mandatory in nine sugarcane producing states in September 2002. However, due to supply shortage the mandate was made optional in October 2006. In October 2007, the government again made it mandatory for 5 per cent ethanol blend in petrol across the country with exception of J&K, the Northeast, and island territories. Now, the policy on biofuels has an ambitious target of 20 per cent blending by 2017 (See table 1.6).

Unlike in the US, Brazil and EU, the biodiesel industry, however, is not as mature and is still in its incubation stage. The demand for diesel is four times the demand for petrol in India. Keeping this and other costs associated with conventional diesel fuel, the GOI formulated the National Biodiesel Mission in 2003. According to the Planning Commission's report, by 2016-17, the demand for diesel is estimated to be around 84 million tones and with a 20 per cent blending requirement, and the need for biodiesel would be around 17 million tones, cultivated in over 14 million hectares in the country.

Table 1.6: Projected demand for petrol and diesel and the biofuel requirements of India

Year	Petrol demand in Mt	Ethanol blending requiremen (in metric tons)			Diesel demand in Mt	Biodiesel blending requirements (in metric tons)		
		@5 %	@10 %	@ 20 %		@5 %	@ 10 %	@ 20 %
2006-2007	10.07	0.50	1.01	2.01	52.32	2.62	5.23	10.46
2011-2012	12.85	0.64	1.29	2.57	66.91	3.35	6.69	13.38
2016-2017	16.40	0.82	1.64	3.28	83.58	4.18	8.36	16.72

Source: Planning Commission, Government of India. Report of the Committee on Development of Biofuel,16th April 2003.

Table 1.7: Ethanol and biodiesel consumption in road transport by region in the New Policy Scenario (mboe/d)

	Ethanol		Biodiesel		Biofuels total		Share of road transport energy use (in per cent)	
OECD	0.7	1.5	0.2	0.8	0.9	2.3	4.0	12.0
Americas	0.6	1.3	0.1	0.3	0.7	1.6	4.0	13.0
United States	0.6	1.2	0.1	0.3	0.7	1.5	5.0	15.0
Europe	0.0	0.2	0.2	0.5	0.2	0.7	4.0	12.0
Non-OECD	0.3	1.4	0.1	0.4	0.4	1.8	2.0	5.0
E.Europe/Eurasia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Asia	0.0	0.7	0.0	0.1	0.1	0.8	1.0	4.0
China	0.0	0.4	0.0	0.0	0.0	0.4	1.0	4.0
India	0.0	0.2	0.0	0.0	0.0	0.2	0.0	4.0
Latin America	0.3	0.8	0.1	0.2	0.4	1.0	10.0	20.0
Brazil	0.2	0.6	0.0	0.2	0.3	0.8	19.0	30.0
World	1.0	2.9	0.4	1.1	1.3	4.1	3.0	8.0
European Union	0.0	0.2	0.2	0.5	0.2	0.7	5.0	15.0

Source: World Energy Outlook, 2013

Indian biodiesel mandate is driven by multiple motivations. Biofuels are seen as a source of renewable energy with potential to create a new industry, to raise farmer incomes and to restore degraded lands, while promoting independence from oil imports and contributing to climate change. Second generation biofuel crops are seen as a possible solution to the biofuel-driven land use change that has raised concerns in both developed and developing countries. The potential diversion or displacement of food crops is now considered a serious problem. Though Indian policy makers were careful and sensitive on this aspect, by envisaging bio-fuel cultivation only on uneconomic lands, the government has not accounted for the displacement of the existing resource gathering and grazing activities by assuming them as wastelands.

India has a mature ethanol industry; however the country is the world's largest sugar consumer, coupled with the fact that the manufacturing costs of ethanol is similar to that of petrol/diesel. The higher cost of cultivation of sugarcane/beets, highly sensitive molasses rates, and the resultant instabilities in the prices has created a ground to search for shift to other bio-diesel options.

In January 2003, the Government of India launched the Ethanol Blended Petrol Programme (EBPP) in nine states and four Union Territories promoting the use of ethanol for blending with gasoline and the use of biodiesel derived from non-edible oils for blending with diesel (5% blending). In April 2003, the National Mission on Biodiesel launched by the Government identified *Jatropha Curcas* as the most suitable tree-borne oilseed for biodiesel production. Due to ethanol shortage during 2004-05, the blending mandate was made optional in October 2004, and resumed in October 2006 in 20 states and 7 Union Territories in the second phase of EBPP. These ad-hoc policy changes continued until December 2009, when the government came out with a comprehensive National Policy on Biofuels formulated by the Ministry of New and Renewable Energy (MNRE) which targeted a 20 per cent blending of biodiesel and bioethonal with mineral diesel and gasoline respectively.

1.4 National Biodiesel Mission 2009

National Biodiesel Mission was proposed in a Planning Commission report of the Committee on Development of Bio-fuel, with an aim to meet 20 per cent of the country's fuel requirements with biodiesel by 2011-12. The policy aims at mainstreaming biofuels and, therefore, envisions a central role for it in the energy and transportation sectors of the country in the coming decades. The policy is expected to bring about accelerated development and promotion of the cultivation, production and use of biofuels to increasingly substitute petrol and diesel for transport and to be used in stationary and other applications, while contributing to energy security and climate change mitigation, apart from creating new employment opportunities and leading to environmentally-sustainable development.

The scope of the policy encompasses bio-ethanol, biodiesel and other biofuels, as listed below:

i. 'bio-ethanol': ethanol produced from biomass such as sugar-containing materials, such as sugar cane, sugar beet, sweet sorghum, etc.; starch-containing materials such as corn, cassava, algae etc.; and cellulosic materials such as bagasse, wood waste, agricultural and forestry residues etc. ;

ii. 'biodiesel': a methyl or ethyl ester of fatty acids produced from vegetable oils, both edible and non-edible, or animal fat of diesel quality; and

iii. other biofuels: bio-methanol, biosynthetic fuels etc. (GOI, 2009)

The key aspect of this policy is to employ non-edible oil seeds cultivated on marginal and wastelands to achieve this target. After extensive research, jatropha seed was considered feasible for oil extraction in Indian Biodiesel mission. It would concentrate on producing enough feedstock for production, testing the viability of processes and to inform and educate the potential participants. The Indian government initially intended to plant jatropha on 11.2 million hectares of wasteland by 2012 and achieve a 10% blending target. However, biodiesel production costs surpassed its purchasing price (which is predetermined by national regulators on a six month basis), thus effectively hindering the ambitious targets proposed by the government. jatropha has never been grown as a commercial crop and its long term response to drought conditions and poor soil fertility is uncertain. Added to this, very little is known about its seed and oil yields when grown in relatively dense block plantations (Achten *et al.*, 2008). The plant's response to fertilizers, water and pruning has not been well established in planting and management practices that vary widely. The annual growth and biomass production are highly variable - even between adjacent plants in the same filed - because the plant material has not yet been defined (Divakara *et al.*, 2009). Large scale cultivation of jatropha must be established before biodiesel production can meet even a 5 per cent blending requirement nationally. However, amid reports of unavailability of the jatropha seed and the overall negative energy balance of biofuel processes, the National Biofuel mission and policy recommendations seems to hang in jeopardy (Negi *et al.*, 2006; Gonsalves, 2006; Singhal and Gupta, 2012).

The target set by the Planning Commission, to be achieved through jatropha cultivation, on wastelands, leads to several unanswered questions. In India, the true availability of wastelands is highly uncertain, a situation largely caused by the overlapping and improper classification of common land, wasteland, and pasture land (Agoramoorthy *et al.*, 2009). The classification of wastelands in India is very ambiguous, with several reports coming up with several different estimations (Table 8). According to the Mohan Dharia Committee on wastelands (1995), who studied the land use statistics available for 305 million hectares out of the 329 million hectares land in the country, there is much confusion regarding wastelands in India ranging from 38.4 million hectares reported by Department of Agriculture and Cooperation to 75.5 million hectares reported by National Remote Sensing Agency (NRSA-1995) to 187million hectares reported by the National Bureau of Soil Survey and Land Use Planning (ICAR). The TERI (2005) report notes that about 5.6 million hectares of wastelands have been allotted to many poor families under various programmes, in addition to a large amount of encroachments for which there is no proper record. Given the widespread poverty in the developing countries that there is no such non-productive or wasteland as the more marginal people are more dependent on land for their livelihood and for their day to day survival.

A government's definition of degraded or wasteland is perhaps informed by the land's previous productivity or by the current absence of agricultural systems that produce commodities for the world market, i.e., bringing in foreign currency and/or tax revenue, which is in odds with the view by local people (Dan Van der Horst and SaskiaVermeylen, 2011). Estimates of biodiesel capacity based on wasteland availability are therefore likely to be inaccurate, which may create misleading cost-benefit analyses. When combined with highly variable seed yields, the displacement of informal land uses creates large uncertainties when determining the implications of widespread jatropha plantation development.

Table 1.8: Wasteland status in India

Sl. No.	Report	Waste land (m.ha)
1	Dept of Agriculture and Cooperation	38.4
2	National Remote Sensing Agency	75.5
3	National Bureau of Soil Survey and Land use	187
4	National Waste Land inventory Project (2000)	63.85
5	National Waste Land Updation project (2003)	55.64
6	Ministry of Rural Development (2010)	47.3
7	Wasteland Atlas of India 2010	63.85

Source: Mohan Dharia Committee (1995) and Wasteland Atlas of India

In the long term, lingo-cellulosic materials are likely to become the primary source of biofuels. It is important in each particular case to evaluate the sustainability of raw material production to ensure that biofuels are developed in areas that do not affect the use of the basic resources of agricultural ecosystems such as soil, water, air and biodiversity (World Energy Council, 2010). Although biofuels for aviation and shipping seem to be the most suitable solution, the implications for land use are enormous for the development of road transport biofuels (Philip et al., 2013). A major debate continues world over about biofuels production and its impact on traditional agriculture, i.e., the perceived competition for land and the risk of displacing production of human and animal food by biofuels. Although land devoted to fuel production could reduce land available for food production, this is at present not a serious problem.

It is against this background that an Indo-US bilateral JCERDC project for Development of Sustainable Advanced Ligno-Cellulosic Biofuels Systems was initiated in America and India with multiple partners in Consortium in each country. The Consortium was led by the University of Florida (UF) in America and the Indian Institute of Chemical technology (IICT) in India. The Centre for Economic and Social Studies (CESS) was associated with the work package component of Sustainability, Marketing and Policy, and is looking into the socio-economic and ecological impacts of biofuels cultivation in India. As a part of this work, a baseline survey was conducted in the state of Madhya Pradesh in India to know the existing scenario with reference to the proposed biofuel crops jowar (sorghum) and bajra (pearl millet). The baseline survey has also looked into the different socio-economic aspects related to the sampled farmers.

Chapter-2
Review of Literature

The study tried to review the experiences from existing literature both from the global context in general and the Indian context in specific. Though there has been little research on Biofuels in India, most research projects are confined to jatropha cultivation and issues related to it. The following section reviews the various issues relating to Biofuels including the national biofuel policy. In India little research has been done on the socio-economic, ecological, food security, and livelihood dimensions of biofuels cultivation, especially on the impacts of the biofuels production from main dryland staple food crops such as Sorghum and Pearl millet. In this study, an attempt has been made to critically review different studies, which have a direct and indirect bearing on the Biofuels cultivation. This review also looks at the sustainability of large-scale biofuel projects and their impact in delivering twin benefits of energy security and environmental sustainability.

Mario Giampietro *et al.* (1997) assessed the feasibility of biofuel production as an alternative to oil by relating the performance of the biofuel energy system to the characteristics of both the socio-economic and environmental system in which the biofuel production and consumption takes place. They highlighted that biofuel can substitute for fossil energy only if the large-scale production of biofuel is biophysically feasible (i.e., not constrained by the availability of land and fresh water sources of energy crop production), environmentally sound (i.e., does not cause significant soil degradation, air and water pollution, or biodiversity loss); and compatible with the socio-economic structure of the society (i.e., requires labor productivity that is consistent with the existing labor supply and per capita energy consumption in the society). They observe that the biofuel system must deliver a sufficiently large amount of net energy to the society per hour of labor employed in the cycle of biofuel production to make the process economically convenient for the society, while generating a sufficiently low environmental loading per unit of net energy supplied to keep the process environmentally sound. They concluded that large-scale biofuel production is not an alternative to the current use of oil and is not even an advisable option to cover a significant fraction on it.

George Francis *et al.* (2005), in their article "A concept for simultaneous wasteland reclamation, fuel production and socio-economic development in degraded areas in India: Need, potential and perspectives of jatropha plantations" highlighted the need for alternative energy for India in the wake of its ever-growing transport needs. Noting that there is more than potential mismatch between the demand and supply of energy needs, they pitched for producing biofuel from jatropha on eroded soils as it promises to achieve both wasteland reclamation and fuel security goals which is in line with Government of India's policy of national development. The authors pitched for the cultivation of jatropha given its advantages to achieve the triple benefits of transportation substitution fuel, soil protection, and economic development. Citing the example of Soy bio-diesel, they opined that the lifecycle analysis shows that it can reduce CO2 and SO2 emissions by 80 and 100 per cent respectively compared to petro-diesel. They further opined that the life-cycle carbon dioxide emissions resulting from the production of bio-diesel from low-input, no-tillage, perennial jatropha plantations (no application of chemicals) would be lower and is likely to be less than 15 per cent compared to petro-diesel.

The study centers on preliminary economic analysis of the production system over a period and is based on the productivity of plants on degraded and currently unusable land with poor soils that have no opportunity costs. While an estimated net internal return of 21.8 per cent can be generated per hectare of jatropha plantation, about 16 per cent internal return is expected for a small-scale biodiesel production plant with processing capacity of 2,000 tons of raw vegetable oil per year. At the same time, the cost of producing a liter of biodiesel stands at 0.50 dollars. Though the results seem to be very viable, they are not produced under the assumption of steady yields and large-scale cultivation, which however proved to be impractical under the Indian circumstances.

Domac J *et al.* (2005), pointed that monetary gains and employment generation are viewed as the prime drivers of the present bio-energy projects. The authors ascertain that given the extreme complex nature of bioenergy and its linkages with a number of aspects, the bioenergy debate should not just be focused on the net return and employment, but, in effect, look into the various other aspects which include social, cultural, institutional and environmental issues. The paper clearly depicts significant contribution of bioenergy as a labor-intensive technology, having the potential of creating employment at national, regional and local levels. However, the employment depends on the different processes employed and the different stages of the conversion process. The authors also ascertain that there is a huge difference between the bioenergy sector in the developed and the developing countries given its various linkages and complexities in it. In developing countries, though bioenergy can provide positive employment and income particularly during the off-harvest season, the current practices employed would make it unsustainable and hence, there is a need for modernizing traditional practices.

Larson (2006), summarizes the results of literature published on LCA studies of liquid biofuels in the transport sector. The review chiefly focuses on the impacts that the production and use of biofuels might have on emissions of GHGs relative to conventional petroleum-based fuels. The study highlights the drawback of lack of proper LCA analysis in the developing countries. He notes that almost all biofuel LCA studies have been undertaken in the European or North American context, while only one good study was available for Brazil and India (both based on ethanol produced from sugarcane). The author rightly observes that though the European and North American context studies provide indicative results, given the context-specific variability and uncertainty around the input parameter values in the LCA analysis, country-or at least region-specific studies are needed for providing quantitatively more meaningful results. The review also highlights the wide range of results in terms of net energy balances and the net greenhouse gas emissions (expressed in terms of equivalent CO2) reported for a given biofuel and originating biomass.

Quirin *et al.* (2004), suggest that the results for any single biofuel pathway span a large range in the per-km savings relative to the use of fossil fuels. The authors note that it is difficult to arrive at unequivocal conclusions regarding the precise quantity of energy and environmental benefits given the diversity of the LCA results. They ascertain that in order to understand the diversity there is a need to examine the details of each study regarding analytical boundaries, numerical input assumptions, and methodologies used to generate the results. They conclude that higher GHG savings with biofuels are likely to be achieved only when there are high and ecologically sustainable biomass yields.

Muller *et al.* (2007), perceive that the food vs fuel debate regarding biofuels is unwarranted as there is no imminent global shortage of land and water to grow a substantial amount of biomass both for food as well as bio-energy production. Though the growing demand for bioenergy will have a negative effect on food as higher food prices increase food insecurity among the poor, on the positive side higher prices and more marketable production can stimulate the agriculture sector by creating better employment opportunities. However, the authors agree that uneven distribution of natural resources, resulting in regional differences would continue to have negative consequences unless trade-related areas are addressed.

Rajagopal (2007) highlights the drawbacks in India's biofuel policy given India's dependence of rural poor on wastelands for diverse purposes. The national biofuel mission emphasizes cultivation of biofuel crops on wastelands; however, majority of these lands are classified as Common Property Resources (CPR), meaning that the community owns the resources collectively. Quoting Gundimeda H (2005), the author establishes that the CPRs contribute between 12 - 25 per cent of the poor household income, and the poorer the household the greater the dependence on CPRs. The study also highlights the loopholes in the categorization of land as wasteland in India, given the change in parameters according to the regions and crops grown. The author states that conflicts are bound to exist if appropriation of wastelands happens without involving of the local communities in decision making, in addition to the problems of the lack of prior experience and absence of minimum support prices for biofuel crops. The author suggests cultivation of multi-purpose short duration crops that can simultaneously yield food/fodder fuel in rotation with food crops as an alternative approach such that even small private farmers can benefit from the opportunities that come from biofuel crops.

Sunil Kumar *et al.*, (2008) in their study on "Economic sustainability of jatropha biodiesel in India", assess the feasibility of bio-fuel production in terms of cost factors. They highlight the necessity of biofuel with reference to fuel shortages and international crude price fluctuations that frequently affect the country. The study also assesses the productive opportunities that are supposed to be created by the bio-fuel industry with reference to employment generation, and reclamation of waste and degraded land. It is estimated that crops such as sunflower, rapeseed, and tree-borne oil seeds such as *Jatropha Curcas* provide rich biomass and nutrients to the soil and check degradation of land - a major problem affecting nearly 65 million hectares in the country. Quoting the Planning Commission's report, they estimate that out of 130 million hectares of wasteland in India, about 33 million are available for reclamation through tree plantation. An economic analysis of feasibility of biofuels in the country done using both primary and secondary data from Bhopal industry shows that while the cost of bio-diesel (specific gravity of 0.85) per liter stood at Rs.30.91, while the retail price stood at Rs.37.81, which is much lesser than the international crude prices. Considering the economics, the authors concludes that jatropha bio-diesel can be more economical than petroleum diesel in the Indian scenario. However, they are of the opinion that though biofuel blending is the need of the hour, nobody in the country is in favor of the implementation of high-tech agrarian methods that need maximum inputs to deliver bumper crops.

Pradip Kumar Biswas *et al.*, (2010), in their research article, "Biodiesel from Jatropha: Can India meet the 20 per cent blending target?" attempt to make an assessment of the state of India's biofuel programme and to identify the hurdles that policy makers need to overcome to achieve the goal of 20 per cent blending. Due to the non-feasibility of using edible oils in India - as the domestic consumption demand often exceeds domestic production, jatropha presents a viable option given its shrubby nature and short gestation period that makes harvesting easier. Added to this, seed collection of jatropha does not coincide with the rainy season when most agricultural activities take place, thusmaking it possible for people to generate additional income in the lean season, not to forget the general advantage of the plant vis-à-vis pest resistance and ability to survive on less fertile land. The authors discuss the important question of availability of land for jatropha cultivation and the methods to bring land under it. While addressing the bottlenecks of biofuel programme and as a conclusion, the authors present the state of commercial production of biodiesel in the country. The first important bottleneck with reference to large-scale production of biodiesel using Jatropha is the different and divergent opinions about the identification and estimation of wastelands/fallow lands in the country. In order to meet the Planning Commission estimated target of 20 per cent blending by 2016-17, the authors project that the need of the hour as economies of scale or large-scale production that reduces prices. The Planning Commission estimates that 20 per cent blending requires 17 million tons of biodiesel that has to be cultivated over 14 mha. However, availability of wastelands, issue of ownership, capital investment, long gestation period, risk of mono-culture, yield fluctuations in different climatic zones, handicaps in terms ofextraction technology and most importantly the issue of price fluctuations, large-scale production of biofuel using jatropha is not feasible in the country. Referring to the approach paper to the mid-term appraisal by TERI (2005) they note that in both forest and government owned wastelands, local communities are not willing to participate unless land ownership is given to them. The authors conclude that the success of the biofuel programme in India depends on solving various problems ranging from land identification, identification of farmers, diffusion of high-yielding crops, and scale of processing plants, prices and subsidies to provide incentives to various stakeholders.

Giovanni Sorda *et al.*, (2010) review the national strategy plans of the world's leading producers over the last decade, with particular attention to blending targets, support schemes, and feedstock use. The article aims to identify the driving forces behind the recent growth of biofuel production, while also focusing on the agricultural products that are directly affected by local support schemes. The authors note that the last ten years (2000-2009) witnessed an increase of fuel ethanol output from 16.9 billion liters to 72 billion liters, while that of biodiesel grew from 0.8 to 14.7 billion liters. This is chiefly driven by government interventions such as mandatory blending targets, tax exemptions, and subsidies. In addition to production and consumption-driven interventions, the government has also intervened on the production chain by supporting intermediate inputs (feed stock crops), and subsidizing value-adding factors including capital and labor, not to forget the import tariffs that protect the domestic industries.

The authors note that without government intervention, production is unprofitable and needs to be driven by external incentives in the form of tax exemptions, subsidies, or any other form of financial incentives. In addition to these strongly distorting policies and criticism on food security, the biofuel lifecycle assessment highlighted a negative net contribution to a reduction in GHG emissions. Hence, the need for second generation of fuel crops is necessitated, which focuses on non-food crops. Given these new challenges and concerns, many countries are adopting new legislations. While the US and EU now require substantial reduction in GHG lifecycle emission, the impact on bio-ethanol and biodiesel production on indirect land use has also been taken in to consideration as manufactures have to now certify the origin of the feedstock. Germany on the other hand has set its future biofuel targets in terms of GHG reductions rather than output volumes. However the authors note that it would be a demanding task to couple capacity expansion with environmentally substantial production, while at the same time limiting biofuel burden on the state budgets.

The study by Pere ArizaMontobbio and Sharachandra Lele (2010) on "Jatropha Plantations for biodiesel in Tamil Nadu, India: Viability, Livelihood Trade-offs and Latent Conflict", focuses on the dimensions of productivity, economic viability, and distribution and latent conflict of biodiesel plantations both at the farm level as well as the household level. They also studied how these observations vary across different socio-economic classes. They argue that integrated assessment of large-scale biofuel production has a 'very low energy return on investment compared to fossil fuels, while at the same time imposing heavy demand on land, water and labour per net GJ delivered. They observe that the government's promotion of cultivation on private lands using state-supported and corporate-supported contract farming approaches in regions of poverty, agrarian distress, and water scarcity have the potential to spark unanticipated conflicts. Citing Fargione *et al.*, 2008, they say that the claimed positive GHG emissions balance will be compromised by the "biofuel carbon debt" of converting forest or shrub ecosystems to energy crops.

The results of the primary study conducted in Tamil Nadu found that the yields are much lower than expected and its cultivation is currently unviable and even its potential viability is strongly determined by water access. Rather than alleviating poverty, the crop impoverishes farmers particularly the poorer and backward sections and also promotes conflict between state and farmer and between different socio-economic classes. Agronomic assessment found that jat?roph?a requires at least three years to start giving consistent economic yields. Though survival rates are high, they differed between rain-fed and irrigated areas, with plots in the irrigated areas reporting better survival. In accordance to the existing literature, the study found that jatropha has high water footprint, as per unit consumption of this plant is 1.5 times more than soya bean and 5 times more than sugarcane/maize. The highest yield in a three-year old plantation ranged from 450 kg/ ha in rain-fed areas to 750 kg/ha in irrigated areas while the globally reported yields show high variability ranging from 0.4 to 12 tonnes/ha.

The economic viability of the plantations studied under three different scenarios of plots - irrigated with electric pumpset, plots irrigated with diesel pumpsets, and rain-fed crops, showed that considering current yields, the net returns are always going to be negative even for irrigated farmers, when assumed that the best case results are at three-year plant maturity (which however is not the reality). When the economic viability of jatropha is compared taking into consideration the opportunity cost of cultivating groundnut, it yielded unprofitable scenarios even under the assumptions of generating experimental level yields and non-factoring of interest burden. Given these poor agro-economic performances close to 30 per cent of the plantations were removed and the other 50 per cent were kept without maintenance.

The impact on livelihoods has also been assessed considering the changes in the items that are valued outside formal markets. It has been noticed that even when the cultivation becomes economically viable, it benefits only large landholders and not people from the lower sections of the society. Crop choice has complex implications for labour demand. Many of the activities in the livelihood portfolio are complementary and address different needs of the household; hence they cannot be conceptually aggregated into a single measure of income. The study also found a significant negative impact on food security as 82 per cent of the respondents were cultivating food crops in the plots which have been now shifted to jatropha and 50 per cent of the total landholding of household converted to this cultivation. A negative tradeoff has been noticed when the opportunity cost of not cultivating groundnut is taken into consideration - an additional Rs.3500 per year per household is incurred with regard to expenses for food (cooking oil), wage labour, and fodder (from biomass of ground; one acre of groundnut or paddy yields cart load of paddy feed bullocks for two months).

Martin Banse *et al.*, (2010), in their research article, "Impact of EU biofuel policies on world agriculture production and land use", discuss the impact of EU biofuel policies by extending the global general equilibrium model Global Trade Analysis Project (GTAP) by including biofuel crops into the analysis. Though the extension does not present biofuels as separate products for final consumption, it enables analysis of the impact of targeted policies such as tax exemptions and obligatory blending for the petrol sector for individual regions and countries. The authors say that though biofuels provide additional income for farmers in an otherwise saturated market, there are also concerns as they tend to increase the volatility of agricultural world prices by linking them with crude oil prices.

The results of the analysis show that enhanced demand for biofuel crops under the EU mandate has strong impact both at the global as well asregional level. The long term trend of declining real world prices of agricultural products slow down or may even be reversed for the feedstock used for biofuels. At the same time, increased incentive to produce also tends to increase land prices in many regions, especially in the South and Central Americas. However, the results depend on the fluctuations of global crude oil prices on the higher side - the higher the crude oil prices, the more competitive the biofuel crops become. The analysis also establishes that the projected changes in production of biofuels would have environmental side effects. As biofuel crops are dependent on scarce resources such as land, water, and other agricultural inputs, they tend to effect the CO_2 balance, soil erosion, and biodiversity. Furthermore, long run investments in R&D, higher yield varieties, better conversion technologies, coupled with strong government intervention are needed for the industry to be competitive. The study also ascertains the need for spatially explicit analysis at the regional level to measure the actual effect of biofuel crop cultivation.

The study by Findalter and Kandilkar (2011) about second generation biofuel stocks in Rajasthan observed the specific local impact of rapid Jatropha plantation development on both government and private lands on rural livelihoods. The study is based in Jhadol Tehsil of Rajasthan, a predominately semi-arid district and a demography dominated by Scheduled Tribes. Jatropha grows naturally in this Tehsil and the villagers have traditionally planted it as a protective fence, while at the same time using its seeds to make soap. Given the relative abundance of wasteland, prior association of the plant to this region, a plantation boom was observed after the launching of the National Mission for Biodiesel in 2003, making this tehsil a frontrunner in the national biodiesel programme.

In Rajasthan, most of the wastelands to be leased in jatropha development are either government-owned or common land previously accessible to farmers and villagers for grazing, forage collection and resource gathering. The study observes that since the poorest villagers typically have the smallest landholdings if any, the disappearance of common grazing land affects them disapportionately, as the use of accessible common land for plantation development may have unintended local consequences by displacing grazing and forage collection. The study also found that the yields have been much lesser than anticipated and they have been handicapped in making use of public or private land, due to the reduction of grass levels on jatropha planted land. The most severely impacted farmers and villagers are those with the smallest landholdings - typically the poorest as they tend to be more heavily dependent on public land for forage. None of the participants reported substantial income from the selling of seeds. Added to this there is an additional burden on them as all the villagers indicated that they had to buy additional fodder in years of low rainfall.

The study by Peter Karacsony *et al.*, (2011) examined the extent to which EU biofuel production and utilization can contribute to sustainable development of environment while at the same time producing long term socio-economic effects. The study notes that to achieve the EU agreement dated 2007, which specifies a 10 per cent component of biofuel mix for 2020 within total fuel consumption, the basic ingredients will have to be cultivated on 38 per cent of the EU soil area with the remaining shared between plant cultivation for food and fodder purposes. The study notes that food supply, biofuel industry, and environmental protection influence each other tightly, with safe supply of food being the most important. In the above connected system, the three factors namely, food, energy and environment compete with each other. Citing the Gallagher Report, they opine that biofuel production impacts safe supply of food which is already skewed due to the imbalance in the distribution of resources in the world. Added to the pressure on land, increase in cereal prices due to biofuels will have a direct impact on developing countries, while in developed countries where higher added animal meat is consumed, there is an indirect impact. The study also notes that the decrease of CO2 and other GHGs by using biofuel depends on the raw materials, and the applied agricultural and production technologies. Citing IEA report on biofuels for Transport's Lifecycle Assessment, the study notes that the best result was reached by the cellulose-based second generation bioethanol (60-100 per cent GHG saving compared to conventional fuel), compared to 80-90 per cent of first generation sugarcane based ones.

Dan Van der Horst and SaskiaVermeylen (2011), in their article "Spatial Scale and Social Impacts of Biofuel Production", provides a critical examination of the impact of biofuel policies within the framework of social impact assessment for both developed and developing countries. The paper explores how the social impacts of biofuel production may be at odds with the push to increase the production of liquid biofuels as global commodities. The authors also attempt to find out when and why negative social impacts are likely to occur and under what circumstances more positive impacts might be expected. The authors note that though biomass energy has the potential to fulfill multiple objectives of environmental, social, developmental/economic, and supply security, in practice the choice of specific policy designs and project types often privileges the achievement of one policy objective at the expense of another. They argue that policies that are designed for a narrowly-defined purpose of security of supply cannot be realistically expected to yield high social or environmental benefits. The production and use of biofuels is never carbon neutral, and at best it is less carbon-intensive than the petroleum products it displaces. Hence, the justification of promoting biofuels hinges to a large extent on the question of how to avoid these negative social impacts and how to obtain positive social impacts.

The authors assess the social impact of biofuels in relation to the Inter-Organizatcional Committee on Guidelines and Principles for social impact assessment (IOCGP), which define social impact as the "consequences to human populations of any public or private actions that alter the way in which people live, work, play, relate to one-another, organize to meet their needs and generally cope as members of the society. They maintain that SIA guidelines can be more easily implemented in a more participatory process, leading to no negative social impacts, even though when a project causes social impacts beyond national boundaries, which this tends to have negative impacts. The article highlights the social impacts of large-scale biofuel among developing countries under three heads namely, land used for increased production, distribution of the different benefits among different sections of society, and the impact of large scale cash crops on rural livelihoods. The authors conclude that none of them have a positive social impact.

The authors rightly note that the displacement effect is also not included in the LCA analysis of liquid biofuels, given that they require a much more interdisciplinary and multi-method approach. The study envisages that the involvement of rural communities in the production of liquid biofuels cannot be evaluated through simplistic proxies such as the number of jobs on the plantation or the average pay per worker. What is required is a much more detailed analysis of how the livelihood strategies and outcomes of rural communities and individuals are transformed by changes in land ownership, land management, and land use associated with the switch toward production of biofuel. The major finding of the study that though production of transport biofuels could bring positive social impacts, these are very unlikely to emerge as automatic by-products of the large-scale production of bioethanol or biodiesel, without strict regulation of the entire supply chain. Large scale and globalized production models are much more likely to result in negative social impacts, caused or exacerbated by the geographical, cultural and power divided between the governments and large companies that are driving this agenda forward and the individuals and communities affected on the ground.

UmeshBabu MS and Sunil Nautiyal (2012), in their study on "Socio-economic and Ecological Consequences of Biofuel Development in India", highlight that biofuels and their production have failed to address challenges such as the supply of water and food security for the growing population in India as well as many other developing countries in the world. Added to shortcomings such as food security and lack of market linkages, the article notes that biofuels which are made from crops require enormous amounts of water which is already getting scarce. Bioenergy is definitely an alternative for fossil fuels, but it will compete with water, which is required for food production. Referring to the report by Stockholm International Water Institute (SIWI), the authors note that by 2050, the amount of additional water needed for bioenergy production could be equivalent to the amount required by the agricultural sector. Hence, the biofuels are not 'the' solution but one of the solutions, and its production could be a great competitor to food production.

Meyer P. M *et al.*, (2013), assessed the Brazilian renewable sector which is considered as a pioneer not only in biofuel (sugar-based ethanol) production but also in the use of ethanol as motor fuel. While highlighting that ethanol substitutes for a little over half of all the gasoline that would otherwise be consumed in Brazil, they assess how the bioethanol industry has affected livestock and agriculture production as well as environmental and socio-economic issues. They note that the success of Brazil's biofuel programme is due to greater consolidation as the gasoline contains 25 per cent of ethanol and its availability at all gas stations. Added to this, about 50 per cent and 90 per cent of the existing and new car fleet are "flex fuel" (dual fuel, running on any proportion of ethanol and gasoline). The authors argue that the lack of structural regulations created greater instability in the production and consumption of alternative fuels leading to cycles of fuel substitution with negative effects to all stakeholders. For example, the sector which grew at the rate of 10 per cent per year between 2000 and 2008, slowed down to 3 per cent after the financial crisis, creating supply constraints for ethanol-based cars.

Comparing different studies based on the regional scenarios of both ethanol and cattle industry in Brazil over 1997 to 2006, the authors conclude that the pressure exerted by the sugar-ethanol industry on livestock is negative, given the appreciation of land prices especially in the areas with high agricultural potential characterized by fertile and well-drained soils and flat topography. In addition to this, the bias of the sugar-ethanol industry to large urban centers further aggravates the problem and leads to shifting of lands from cattle cultivation to sugarcane cultivation. As of a result, livestock activity and the people who depended on this experienced three different situations: 1) local migration where the farmers abandoned livestock cultivation due to inadequate knowledge of sugarcane cultivation, thereby leasing out their lands. This phenomenon of rural exodus is more observed among small and medium farmers in the southeast region who migrated mostly to Sao Paulo. 2) Regional migration, which motsly affected medium farmers who exchanged their farms in the southeast region for extensive areas at the agricultural frontier in the midwest and north regions, resulted in clearing of native forest areas to move cattle to untouched areas. 3) Technological migration - the pressure exerted by the bioethanol industry on livestock by rising land prices resulted in technological migration as it led to change from an extensive production system to an intensive production system that requires highly-specialized techniques.

Conclusions

Liquid fuels from biomass have already entered commercial markets in many countries especially as blends with gasoline and diesel. Though India has scope for developing biofuels for substituting conventional fuels and achieving energy security due to availability of raw material, a review of the existing literature points out that R&D, suitable policy support, and most importantly the global market balances are required for avoiding negative externalities. Given that a vast majority of the population and livelihoods are interlinked to the agriculture and its surrounding environmental balances, a fine blend of policy decisions and technological breakthroughs are the need of the hour for achieving positive social impacts or at least to do away withthe negative social impacts. Achieving energy security for the country through alternate methods is an important area being focused by the Indian policy makers. However, any attempt to promote the use of major staple food crops such as Jowar and Bajra for biofuels production has a long-lasting impact on the food, fodder and nutritional security of millions of people and livestock in India. Cultivation of high biomass jowar and bajra varieties on a large scale could pose a serious threat to the existing rich diversity in these crops. Hence, even for trying out these crops at the research level, it is very essential to have a dialogue with the farmers of the dry lands, where these two crops are predominantly grown. The voice of small and marginal farmers and women should be heard before moving further into utilizing these crops for biofuel production. More importantly, we should learn from our earlier experiences of jatropha cultivation. Large-scale biofuel production is not an alternative to the current use of oil and is not even an advisable option to cover a significant fraction of it (Giampietro *et al.*, 1997). The production of feed stocks for biofuels would put additional pressure on agricultural resources such as land and water. Therefore, it is quite important that policies, plans and strategies for energy security do not conflict with other aspects of critical national importance like food security.

The review projects a mixed picture about the economic, environmental and social viability of biofuels. Except for the experiences related to jatropha, no literature is available with reference to biofuel production from food-based crops in India. Experiences from Europe and other South American countries however provide learning opportunities with regard to policy, technology barriers especially in terms of conversion, problems associated with trade linkages, and most importantly long-run economic viability. A strong synergy of rationales such as the prospect of reduction in external dependence, better environment and creation of additional employment opportunities make a strong case for promotion of biofuels in India. However, reviews suggest that it is difficult to achieve all of the objectives simultaneously and it would be a demanding task to couple capacity expansion with environmentally substantial production, while at the same time limiting biofuel burden on the state budgets. The outlook for biofuels is also highly sensitive to possible changes in government subsidies and blending mandates, which remain the main stimulus for biofuels use. Over the past year, much uncertainty has developed about how biofuel policies in several key markets will evolve (IEA, 2013).

The production and use of biofuels is never carbon-neutral, and at best it is less carbon-intensive than the petroleum products it displaces. There is also a huge difference between the bioenergy sector in the developed and the developing countries given its various linkages and complexities. In developing countries, though bioenergy can provide positive employment and income particularly during the off-harvest season, the current practices employed would make it unsustainable and hence there is a need for modernizing traditional practices. Most of the alternative energy policies are designed for a narrowly-defined purpose of supply security and cannot be realistically expected to yield high social or environmental benefits. Hence, the justification of promoting biofuels hinges to a large extent on the question of how to avoid these negative social impacts and how to obtain positive social impacts. The important barriers for successful implementation of biofuels come from the farmers - the chief stakeholders, and given the fact that India's majority livelihoods are linked and re-linked to agriculture, caution must be exercised in promoting biofuel production from food-based crops.

Chapter-3
Research Objectives and Methods

Indo-US bilateral JCERDC project for Development of Sustainable Advanced Ligno-cellulosic Biofuels Systems had an important work package component of Sustainability, Marketing and Policy. In this project, the Centre for Economic and Social Studies was looking into the socio-economic and ecological impacts of biofuels cultivation in India. As a part of the study,a baseline survey was conducted in the State of Madhya Pradesh in India with the following objectives:

3.1 Objectives of the Study

1) To know the existing scenario with reference to the proposed biofuel crops, Jowar (Sorghum) and Bajra (Pearl Millet), in the study area.
2) To understand the socio-economic aspects of sampled farmers.
3) To assess the economics of Jowar and Bajra crop cultivation of the sampled farmers.
4) To examine the ecological, social and livelihood significance of biofuel crops cultivation.
5) To understand the awareness levels of sampled farmers regarding biofuel cultivation and its impact of food and fodder security.
6) To contribute to the overall policy discourse on biofuels cultivation in India.

3.2 Study Area, Data Collection, and Methodology

The total crop area covered in India during 2012-13 was 165,098 thousand hectares. Out of this Kharif and Rabi area was 103,849 and 61,249 thousands respectively. In Madhya Pradesh during the year 2012-13, the total cropped area was 23,461 thousand hectares. The area under Kharif and Rabi crops was 12,025 and 10,316 thousand hectares respectively. Table 3.1 indicates that Maharashtra and Rajasthan ranked first in the area under jowar and bajra cultivation respectively, followed by Karnataka and Rajasthan in case of jowar and Maharashtra and Karnataka in case of bajra. However, the JCERDC Project on SALBs has decided to work in the states of Madhya Pradesh and Gujarat.

One of the important reasons for choosing Madhya Pradesh could be the presence of RVSKVV and the strong support they extend in conducting the multi-locational trials in the research stations as well as farmers' fields. CESS is coordinating the work package component of SALBs in the State of Madhya Pradesh (MP) and hence has undertaken the baseline study during the year by May 2013. It can be seen from table 3.1 that the biofuel crops jowar and bajra account for only 3.78 per cent and 5.32 per cent respectively to the total cropped area covered.

In Madhya Pradesh, the total population (Census 2011) is 72.6 million as against India's 1210.6 million. The growth rate of population in India during the last decade is 17.7% whereas it is 20.3% in Madhya Pradesh. The sex ratio in Madhya Pradesh which was 919 in 2001 has increased by 12 points to 931 in 2011 (as against India's 933). In India, the proportion of the Scheduled Caste population constitutes 16.6% of the total population according to the2011 Census and it is 15.6% of the state's population in MP. Contrary to this, the Scheduled Tribe population constitutes 21.1% of the state's total population whereas at the all India level it is only 8.6%(2011 Census). The effective literacy rate in Madhya Pradesh is 69.3% (Rural - 63.9%; Urban - 82.8%) marking an increase of 5.6 percentage points (6.1 percentage points in rural areas and 3.4 percentage points in urban areas) during the last decade. In Madhya Pradesh, as per Census 2011, out of 31.6 million total workers, 9.8 million are cultivators and another 12.2 million are agricultural labourers. Thus, nearly 69.8% of the workers are engaged in agricultural activities compared to nearly 71.5% in Census 2001. Therefore, still more than two-thirds of the total working population is engaged in agricultural pursuits either as cultivators or as agricultural labourers. Two out of every three males and four out of every five females are engaged in agricultural activities either as cultivators or as agricultural labourers. Of the remaining workers, 1.0 million are in household industries and 8.6 million are among other workers.

Even today, two-thirds of the total working population are engaged in agricultural pursuits either as cultivators or as agricultural labourers. Majority of the farmers are small and marginal farmers. Madhya Pradesh has the distinction of much diversified livestock resources. In MP, agriculture has been undergoing many changes over the past two to three decades and today it stands first in the country with respect to agricultural transformation growth. The increasing intervention of the state in agriculture, and the green and yellow revolutions, have prompted agricultural changes throughout the semi-arid regions, especially in land ownership, cropping patterns, irrigation, credit and extension, agricultural productivity, prices and marketing. The use of fertilizers was lesser in MP than the national average. In the year 2012-13, the total NPK per hectare consumption was 84.8 kg/ha as against the India's 128.11 kg/ha (Fertiliser Association of India, 2013).

Table 3.1: Area under different cereal and millet crops in India during 2011-12 (000' hectares)

State	Rice	Jowar	Bajra	Maize	Ragi/ Maura	Wheat	Barley	Other Cereals and Millets	Total Cereals and Millets
Andhra Pradesh	4096	276	43	864	42	8	-	29	5358
Arunachal Pradesh	124	-	-	47	-	4	-	22	196
Assam	2537	-	-	21	-	53	-	6	2617
Bihar	3324	2	5	675	8	2142	11	6	6172
Chattisgarh	3774	5	0	104	8	109	3	149	4151
Goa	47	-	-	-	0	-	-	-	47
Gujarat	836	124	867 (3rd)	516	16	1351	-	69	3779
Haryana	1235	65	577 (5th)	9	-	2522	42	-	4450
Himachal Pradesh	77	-	-	294	2	357	22	6	758
Jammu and Kashmir	262	-	19	314	-	296	7	14	913
Jharkhand	1469	1	-	216	12	159	-	-	1856
Karnataka	1416	1142 (2nd)	286 (6th)	1349	680	225	-	24	5122
Kerala	208	-	-	-	-	-	-	-	209
Madhya Pradesh	1662	395 (4th)	179 (7th)	863	-	4889	81	249	8318
Maharashtra	1543	3279 (1st)	838 (4th)	881	130	843	3	67	7548
Manipur	224	-	-	25	1	2	-	-	251
Meghalaya	109	-	-	17	-	-	-	2	129
Mizoram	39	-	-	7	-	-	-	-	46
Nagaland	182	-	1	69	-	3	1	9	263
Odisha	4005	9	3	103	55	2	-	17	4193
Punjab	2818	-	3	126	-	3528	12	-	6487
Rajasthan	134	554 (3rd)	5020 (1st)	1046	-	2935	278	16	9983
Sikkim	12	-	-	40	5	3	1	3	63
Tamil Nadu	1904	198	47	281	83	-	-	30	2544
Tripura	266	-	-	4	-	-	-	-	270
Uttarakhand	280	-	-	28	125	369	23	72	897
Uttar Pradesh	5947	192	888 (2nd)	787	-	9731	158	9	17712
West Bengal	5434	-	-	98	8	316	2	1	5859
Total	**43964**	**6242**	**8776**	**8784**	**1175**	**29847**	**644**	**800**	**100191**

Source: Ministry of Agriculture, GOI 2012.

All the above-mentioned aspects have a huge bearing on the biofuels cultivation, especially in the dryland regions. It was in this context that Madhya Pradesh was selected for the baseline survey study focusing on the socio-economic, ecological, food security, and livelihood dimensions of biofuels production through the food crops such as Sorghum and Pearl millet.

The selected districts were Gwalior, Khargone, Dewas, Morena and Bhind. Districts hosting Sorghum and Pearl millet in large areas, were selected for the study. A total of ten villages were selected from five districts where the trials of high biomass feedstocks are to be conducted by work package one partners of the project. Stratified proportionate random sampling was used covering 333 farmers belonging to different size classes in 10 villages (See table 3.2). The study used both qualitative and quantitative methods for understanding the farmers socio-economic and ecological aspects of jowar and bajra and the awareness about biofuels production through these crops. Personal interviews were conducted with a structured interview schedule. The study used an *ex post facto* research design and Focused Group Discussions (FGDs). Secondary data on land use, fertilizer use, and demographic features of the district were collected from the survey reports by the Directorate of Census, Madhya Pradesh, Fertiliser News, and Ministry of Agriculture.

3.2.1 Household Questionnaire

A structured questionnaire was used to collect the data from the selected sample households from the ten selected villages. The interview schedule, comprising the measurement of variables was prepared in consultation with experts, keeping in view the objectives of the study. Piloting of the questionnaire was done in Santa and Janarpura villages outside the sample area. In the light of the experience gained in the pre-testing, suitable modifications were made before finalizing the interview schedule. The field survey was carried out during May to July 2013.

Enumerators were used for collecting the information through the household questionnaire. In the beginning, the selected enumerators were given three days of training at Rajamata Vijayraje Krishi Vishwa Vidyalay (RVSKVV) on how to canvas the questionnaire and help them to understand the general issues of jowar and Bajra cultivation. After the training exercises, a trial field visit was undertaken to one of the five sample districts where enumerators were asked to canvass the household interview schedule. This was useful for enumerators to get to know the local conditions and clarify further doubts on the concepts used in the questionnaire.

The structured questionnaire used for the baseline study covered aspects such as household description, demographic particulars, farm cycle, land-related plot-wise details, farm

Table 3.2: Details of the sample households selected for the study in Madhya Pradesh

District/Block/Village	Total Landed Households in the Village	Total Jowar/ Bajra Households in the Village	Sampled Households 0.1 - 2.5 acres	2.51 - 5.0 acres	5.1 - 10 acres	10.1 and above	Total Sample
Gwalior District							
Bijoli	332	119	12	8	1	1	22
Daheli	110	107	5	4	5	3	17
Jhakara	368	350	23	17	6	6	52
Morena District							
Ummedganbhasi	372	362	38	12	8	4	62
Nahardowki	144	142	12	6	3	1	22
Khargone District							
Nagazari	475	357	21	14	12	7	54
Rupkheda	167	103	5	9	1	0	15
Dewas District							
Nagdha	250	114	9	4	3	1	17
Chinvani	133	113	9	5	3	1	18
Bhind District							
Baraha	374	363	27	13	6	8	54
Total sample			**161**	**92**	**48**	**32**	**333**

economics, crop-wise cost of cultivation, livestock economy prevalent in the village, household savings and credit details, household expenditure, migration details of household, awareness on biofuels and questions related to farmers' response with respect to biofuels vis-à-vis food/fodder security.

3.2.2 Focused Group Discussions (FGDs)

FGDs were conducted with land owners of all sizes of holdings. The objective of these discussions was to have a general idea on jowar and bajra cultivation and the related issues . FGDs helped to understand the livelihoods, food and fodder security issues of biofuels. This helps to bring out the perspectives of various categories of people with reference to jowar and bajra cultivation for biofuels production.

3.2.3 Methods for Data Analysis

The data analysis was basically conducted in two ways. One was comparing between the various size classes of large, medium and small farmers. The results of the study are discussed at two levels: one at the household level and the other at the plot level. The data gathered was analysed using different statistical tools. Averages, frequency and percentages were used to analyse the various information related to jowar and bajra cultivation.

3.2.4 Report Structure

The report is organised in 4 chapters. Chapter one gives an introduction to this work. In this chapter, the overall scenario about biofuel cultivation in India is presented. The advantages and disadvantages of biofuel cultivation are discussed. The second chapter reviews the literature on biofuels cultivation in general and Indian experiences in particular. This is followed by objectives and methodology in Chapter 3. The fourth chapter discusses the socio-economics of soil fertility management. Data on demographic features, land use patterns, livelihoods, socio-economic aspects of the sample households are discussed in this chapter along with final concluding remarks.

Chapter - 4
Socio-Economic Analysis of the Farmers

In this chapter an attempt is made to understand the socio-economic profile of sample farmers and the issues related to sorghum and pearl millet cultivation. The demographic features of the sample villages and livelihood patterns seen in the selected villages are discussed. The socio-economic features, age group, literacy level, livestock population, market distance, farming experience, social participation, caste composition, landholding, net income and borrowings, awareness on biofuels cultivation, use of jowar crop for biofuel production and its impact on food and fodder are some of the important issues discussed in the latter part of this chapter. This analysis is expected to provide information about the representativeness of the sample villages and help in getting an insight into the issues of jowar/Bajra crop cultivation for biofuel production. The following sections present the empirical findings of the baseline study in Madhya Pradesh with respect to different socio-economic aspects related to sample farmers. The sample is taken in such fashion that it reflects the socio-demographic structure of the village. That would reflect the impact of cultivation of bio-fuels across different social structures.

4.1 Caste

In order to understand the social and economic dynamics of the sample villages, one has to look into the social system, which largely determines people's perceptions, values and knowledge. Caste is also synonymous with occupation and livelihood in the rural context.

While majority of the districts observed in the state have a substantial OBC (Other Backward Castes) population, there is also a substantial presence of Scheduled Castes (SCs) and Scheduled Tribes (STs) - the most vulnerable households - in the study villages (see table 4.1). It has to be noted that the Rupkheda Village in Khargone District has 100% tribal households which allows a study of the impact dynamics among them. Among the total sample households, 58 per cent belonged to Backward Communities (BCs) followed by Other Castes (OCs) 17.40 per cent, SCs 15.3 per cent and STs 9.33 per cent.

Table 4.1: Distribution of respondents according to their social category in study villages of Madhya Pradesh during 2012-13

District Name	Village Name	SC	ST	OBC	Others	Total
DEVAS	Nagada	5.9	5.9	47.1	41.2	100.0
		(1)	(1)	(8)	(70)	(17)
	Chinvani Mahankal	0.0	5.6	94.4	0.0	100.0
		(0)	(1)	(17)	(0)	(18)
Khargone	Nagziri	0.0	13.0	77.8	9.3	100.0
		(0)	(7)	(42)	(5)	(54)
	Rupkheda	0.0	100.0	0.0	0.0	100.0
		(0)	(15)	(0)	(0)	(15)
Bhind	Baraha	11.1	1.9	64.8	22.2	100.0
		(6)	(1)	(35)	(12)	(54)
Gwalior	Bijoli	27.3	13.6	45.5	13.6	100.0
		(6)	(3)	(10)	(3)	(22)
	Daheli	35.3	0.0	58.8	5.9	100.0
		(6)	(0)	(10)	(1)	(17)
	Jakara	36.5	3.8	53.8	5.8	100.0
		(19)	(2)	(28)	(3)	(52)
Morena	Nahar Donki	13.6	0.0	50.0	36.4	100.0
		(3)	(0)	(11)	(8)	(22)
	Ummed garh	16.1	1.6	51.6	30.6	100.0
		(10)	(1)	(32)	(19)	(62)
	Total	**15.3**	**9.3**	**58.0**	**17.4**	**100.0**
		(51)	(31)	(193)	(58)	(333)

Source: Field Survey

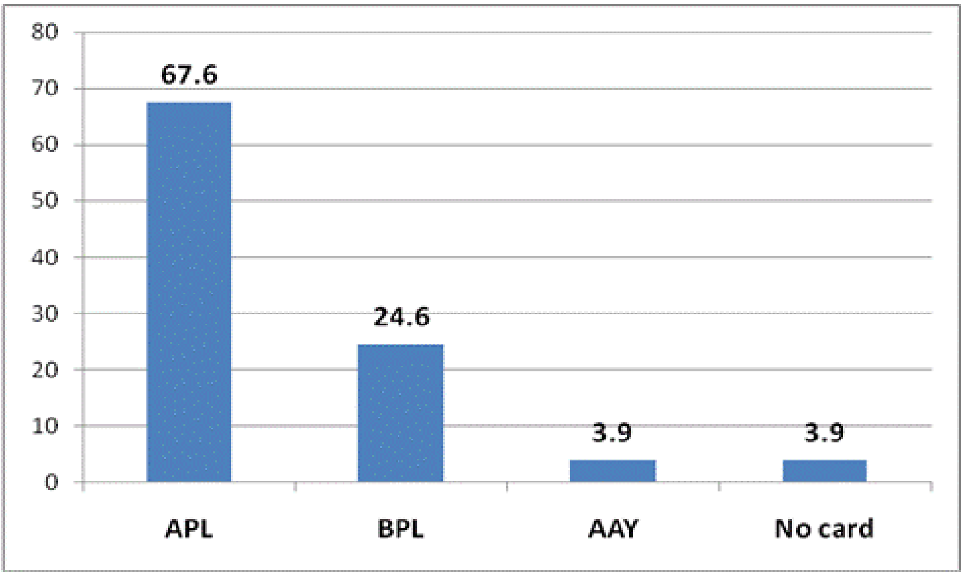
Note : The figures in the parenthesis are actual number of households.

It is clear from the figure 4.1 that the majority (67.6 per cent) of the sampled households are Above Poverty Line (APL), followed by 24.6 per cent Below Povert Line (BPL). Furthermore, households having Anthyodaya (AAY) cards are 3.9 per cent and the same percentage of households have no cards.

4.2 Literacy

Education was operationalised as the number of years of formal schooling attended by the sample farmer. For the purpose of distribution of farmers, six

Fig.4.1: Distribution of sampled households according to the ownership of ration cards in the study area during 2013-14



Source: Field Survey

categories were identified not literate, literate but did not complete primary school, primary, upper primary, SSC, Intermediate, Graduation, and above.

It is presumed that literacy generally equips an individual with an analytical outlook towards a problem and rational behavior, in general, as compared to the illiterate. Even regarding soil fertility management, this holds good. There is a general feeling that an average Indian farmer can be more effective if he is educated, and it is presumed that if a farmer is educated he can be made aware of better methods of farming. More importantly, it would be relatively easier for the extension agencies to communicate information regarding recent advances in crop husbandry to a literate farmer. Hence, an attempt has been made to enquire into the educational background of the respondents and the percentage of farmers in various educational levels in the respective size class; the total number of sample households was also calculated.

It is evident from table 4.2 that among the total sample farmers, 29.10 per cent were not literate, followed by upper primary (23.10 percent), and SSC (15.90 per cent). This could be due to lack of proper educational infrastructure in these villages. Another reason could be financial constraints and the need to work for the sustenance of their families. Only 2.1 per cent of the sample farmers were graduates. Among the study villages, the literacy level was better in case of Ummedgarh Village. Contrastingly, among the sample farmers of Rupheda Village, 80 per cent of them were not literates. This might be due to lack of better educational facilities, coupled with the presence of ST families, who were traditionally lagging behind in the literacy level due to lack of awareness about the importance of education.

4.3 Family Size

This refers to the total number of people in the sample farmers' families, usually consisting of husband, wife, children and other members. Majority (63.1 per cent) of the sampled households in the study area have joint family system which is quite contrary to the emergence of nuclear family system in other parts of India (see table 4.3). This will enable the better availability of family labour in farming in general and biofuel production in particular.

It is evident from table 4.4 that primary occupation in the study area was farming followed by agricultural casual labour. Similarly, livestock was predominantly secondary occupation for many sampled households. Own business, self employment and salaried work were other occupations taken up as primary and secondary occupations by some households. Dependence on Common Property Resources (CPRs) for their occupation was negligible in the study sites.

Current fallows are observed only in Nagziri. Villages such as Baraha, Bijoli, Daheli, Jakara, Nahar Donki, and Ummed Garh have no area under both current as well as permanent fallows. Thus, table 4.5 offers little hope of utilizing current or permanent fallows for biofuel production due to less area under these categories.

4.4 Availability of Marginal Lands in Madhya Pradesh

One of the major objectives of the project is to utilize the existing wastelands in Madhya Pradesh to cultivate high biomass producing jowar and bajra varieties. It can be seen from table 4.6 that only 3.93 per cent of the land (1.2 million hectares) is culturable waste in Madhya Pradesh. Out of this, how much land can be brought under cultivation is a question which can be answered only in future; and this depends on whether the fertility level of these soils is capable enough to support the cultivation of high biomass producing varieties which are generally input-intensive. If we do not aim at these lands and instead promote

Table 4.2: Distribution of respondents according to their education level in the study area of Madhya Pradesh during the year 2012-13

District Name	Village Name	Illiterate	Literate but didn't complete PS	Primary	Upper	SSC Primary	Inter	Graduation	Total
DEVAS	Nagada	11.8 (2)	58.8(10)	11.8 (2)	11.8 (2)	5.9 (1)	0.0 (0)	0.0 (0)	100.0 (17)
	Chinvani Mahankal	16.7 (3)	22.2 (4)	11.1 (2)	22.2 (4)	22.2 (4)	5.6 (1)	0.0 (0)	100.0 (18)
Khargone	Nagziri	25.9 (14)	11.1 (6)	16.7 (9)	24.1 (13)	11.1 (6)	9.3 (5)	1.9 (1)	100.0 (54)
	Rupkheda	80.0 (12)	20.0 (3)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	100.0 (15)
Bhind	Baraha	46.3 (25)	3.7 (2)	13.0 (7)	22.2 (12)	7.4 (4)	3.7 (2)	3.7 (2)	100.0 (54)
Gwalior	Bijoli	18.2 (4)	0.0(0)	0.0(0)	27.3 (6)	40.9 (9)	13.6 (3)	0.0(0)	100.0 (22)
	Daheli	41.2 (7)	11.8 (2)	29.4 (5)	11.8 (2)	5.9 (1)	0.0(0)	0.0(0)	100.0 (17)
	Jakara	28.8 (15)	5.8 (3)	7.7 (4)	26.9 (14)	21.2 (11)	5.8 (3)	3.8 (2)	100.0 (52)
Morena	Nahar Donki	22.7 (5)	0.0(0)	18.2 (4)	22.7 (5)	27.3 (6)	9.1 (2)	0.0(0)	100.0 (22)
	Ummed garh	16.1 (10)	6.5 (4)	11.3 (7)	30.6 (19)	17.7 (11)	14.5 (9)	3.2 (2)	100.0 (62)
	Total	**29.1 (97)**	**10.2 (34)**	**12.0 (40)**	**23.1 (77)**	**15.9 (53)**	**7.5 (25)**	**2.1 (7)**	**100.0 (333)**

Source: Field Survey,
Note: The figures in the parenthesis are actual number of households.

high biomass jowar and bajra varieties in the existing cultivated lands, it will affect the food and fodder security of the farming households of the region when the project is upscaled.

Table 4.3: Distribution of Sampled Households according to their family size during the year 2012-13

District	Village Name	Joint Family	Nuclear Family	Total
DEVAS	Nagada	94.1 (16)	5.9 (1)	100.0 (17)
	Chinvani Mahankal	83.3 (15)	16.7 (3)	100.0 (18)
Khargone	Nagziri	35.2 (19)	64.8 (35)	100.0 (54)
	Rupkheda	(5) 33.3	66.7 (10)	100.0 (15)
Bhind	Baraha	90.7 (49)	9.3 (5)	100.0 (54)
Gwalior	Bijoli	86.4 (19)	13.6 (3)	100.0 (22)
	Daheli	94.1 (16)	5.9 (1)	100.0 (17)
	Jakara	86.5 (45)	13.5 (7)	100.0 (52)
Morena	Nahar Donki	31.8 (7)	68.2 (15)	100.0 (22)
	Ummed garh	30.6 (19)	69.4 (43)	100.0 (62)
	Total	**63.1 (210)**	**36.9 (123)**	**100.0 (333)**

Source: Field Survey

Note: The figures in the parenthesis are actual number of households.

Table 4.4:Distribution of sampled households according to their occupation (percentage)

Occupation	Primary Occupation	Secondary Occupation
Agriculture	87.38 (291)	9.41 (24)
Agril. casual labour	4.50 (15)	17.25 (44)
Salaried agriculture worker	0.30 (1)	0.0 (0)
Own business	1.80 (6)	3.92 (10)
Self-employed in household industry	0.90 (3)	0.78 (2)
Non-agril casual labour	1.20 (4)	9.80 (25)
Salaried work	1.50(5)	1.17 (3)
Common property resources	0.30 (1)	0.0 (0)
Livestock management	2.10 (7)	57.64 (147)
Total	**100.0 (333)**	**100.0 (255)**

Source: Field Survey

Note : The figures in the parenthesis are actual number of households.

Table 4.5: Area under fallow (in acres) in the study area during the year 2012-13

Village	Current Fallows	Permanent Fallows	Total
Nagada	1.5	1	2.5
Sunvani Mahankal	11.5	0.5	12
Nagziri	108.75	18	126.75
Rupkheda	26	3	29
Baraha	0	0	0
Bijoli	0	0	0
Daheli	0	0	0
Jakara	0	0	0
Nahar Donki	0	0	0
Ummed garh	0	0	0
Grand Total	**147.75**	**22.50**	**170.25**

Source: Field Survey

Table 4.6: Land use details of India and Madhya Pradesh State during the year 2011-12 (000'hectares)

Particulars	India	Madhya Pradesh
Geographical area	328726	30825
Forests	70015 (21.29)	8681(28.16)
Area under non-agriculture uses	26294 (8.19)	1890 (6.13)
Barren and uncultivated land	17227 (5.24)	1417(4.60)
Permanent pastures	10296 (3.13)	1394 (4.52)
Land under miscellaneous tree crops and groves	3164 (0.96)	19(0.06)
Culturable waste land	12636 (3.84)	1213 (3.93)
Fallow lands other than current fallows	10666 (3.24)	626(2.03)
Current fallows	14715 (4.48)	997(3.23)
Net area sown	140801 (42.83)	14518 (47.09)
Total cropped area	195246 (59.39)	18078(58.64)
Area sown more than once	54444 (16.56)	3560 (11.55)

Source: Directorate of Economics and Statistics, Department of Agriculture and cooperation of Ministry of Agriculture, GOI and Ministry of Statistics and Programme Implementation.

Note: Figures in the parenthesis are percentages to total geographical area

According to Ministry of Rural Development (MoRD), there is 13.01 per cent of wasteland in the state as compared to the total geographical area in the state (see table 4.7). Similarly, according to the Waste Lands Atlas of India, 2011, the area of waste lands in Madhya Pradesh is 4.01 million hectares. Furthermore, even at the national level there is a huge difference in the areas reported under waste land by different agencies (Reddy *et al.*, 2014). For example, according to the Ministry of Rural development, the area of waste lands in 2010 is 47.3 million hectares as against the Waste Land Atlas data of 63.85 million hectares for the same year. Given the lack of clarity on the exact waste land area available, the argument for promoting sorghum and pearl millet production in these waste lands in future is a questionable proposition.

Table 4.7 : Total area under waste lands in Madhya Pradesh state and India during 2008-09 (00'hecatres)

State	Total Geographical areas	Total waste land	Percentage of waste land to total geographical area
Madhya Pradesh	308252	40113.27	13.01
India	3166414	467021.16	14.75

Source: Ministry of Rural Development, Govt of India and Compendium of Environmental Statistics, Govt. of India

4.5 Soil Fertility

The present research tried to assess the level of soil fertility of sample plots according to farmers' own perception. For this purpose, all the 691 plots owned by sampled households were compared with the best fertile plot in the respective village (based on FGDs). The soils of the farmers were evaluated on a scale of continuum consisting of very bad, bad, average and good. Table 4.8 indicates that the majority (53 per cent) of the sampled plots are having a depth of more than 4.1 feet followed by 2.1 to 3 feet. However, a majority (48.6 per cent) are interestingly having average soil quality as perceived by farmers and 25.3 per cent of the sampled plots are of good quality (see figure 4.2). This has implication for high biomass jowar cultivation as soil fertility will directly affect crop yield. Plots with bad soil quality were 22 per cent and very bad were 4.1 per cent. The low fertility status could be due to gradual decline in organic manure application and intensive cultivation. The study by Reddy (2010) reported that 37.13 per cent of the plots were perceived to be of average fertility status and only 10.25 per cent had good soil fertility.

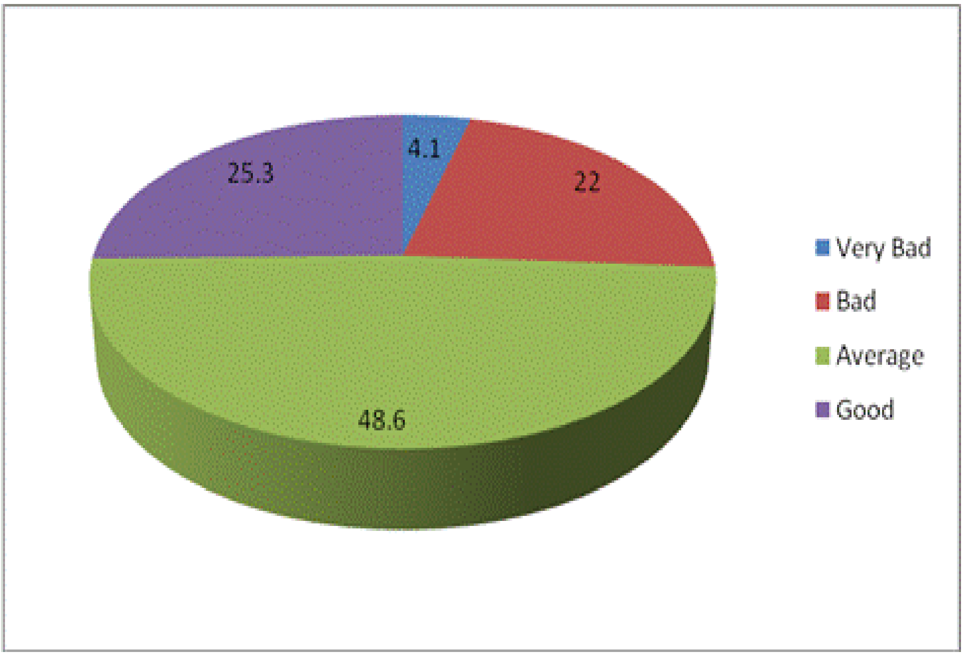
Table 4.8: Distribution of Sampled plots according to their Soil depth during the year 2012-13

Village	Soil Depth					Total (N=691)
	Upto 1 feet (Very Shallow)	1.1 to 2 feet (Shallow)	2.1 -3 feet (Medium)	3.1-4 feet (Deep)	4.1 feet and above (Very Deep)	
Nagada	22.2 (6)	18.5 (5)	22.2 (6)	11.1 (3)	25.9 (7)	100.0 (27)
Chinvani	11.4 (4)	2.9 (1)	8.6 (3)	17.1 (6)	60.0 (21)	100.0 (35)
Nagziri	36.1 (44)	52.5 (64)	11.5 (14)	0.0 (0)	0.0 (0)	100.0 (122)
Rupkheda	54.2 (13)	33.3 (8)	8.3 (2)	4.2 (1)	0.0 (0)	100.0 (24)
Baraha	0.0 (0)	26.7 (20)	52.0 (39)	6.7 (5)	14.7 (11)	100.0 (75)
Bijoli	0.0 (0)	2.7 (1)	35.1 (13)	5.4 (2)	56.8 (21)	100.0 (37)
Daheli	0.0 (0)	5.0 (2)	5.0 (2)	2.5 (1)	87.5 (35)	100.0 (40)
Jakara	0.0 (0)	4.8 (5)	33.3 (35)	5.7 (6)	56.2 (59)	100.0 (105)
Nahar Donki	0.0 (0)	8.6 (6)	0.0 (0)	0.0 (0)	91.4 (64)	100.0 (70)
Ummed garh	0.0 (0)	3.8 (6)	0.6 (1)	0.0 (0)	95.5 (149)	100.0 (156)
Total	**9.7 (67)**	**17.1 (118)**	**16.6 (115)**	**3.5 (24)**	**53.1 (367)**	**100.0 (691)**

Source: Field Survey,

Note : The figures in the parenthesis are actual number of households.

Figure 4.2: Respondents perception about soil quality of sampled plots



Source: Field Survey

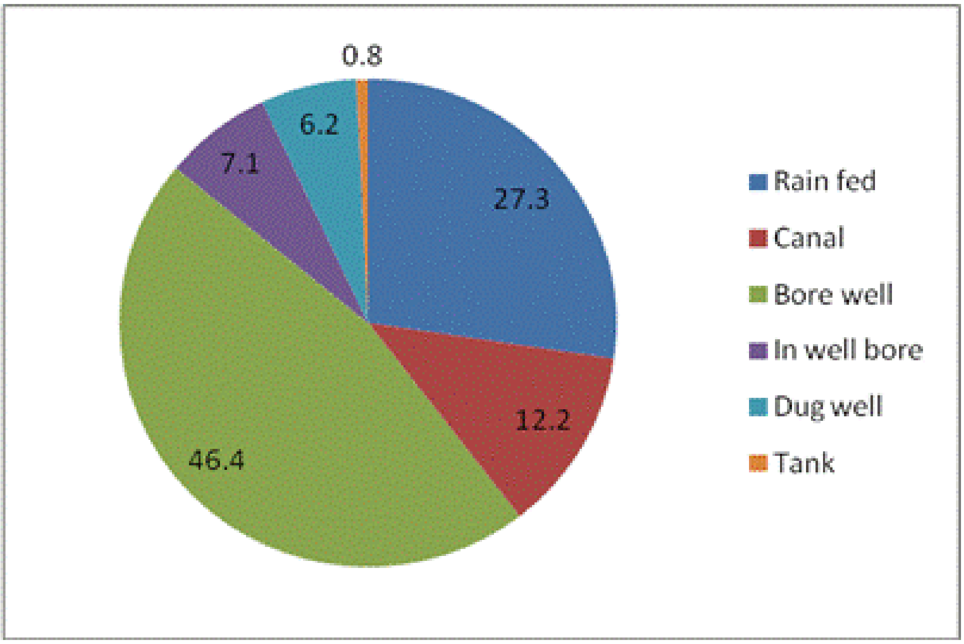
4.6 Irrigation Source

The study area has diverse sources of irrigation including rainwater for crop cultivation. Figure 4.3 indicates that borewell is the major source of irrigation (46.4 per cent), followed by rainfall (27.3 per cent), and canal irrigation. Additionally, in well bores, dug wells and tank irrigation were other sources of irrigation. Among methods of irrigation, flooding was predominant, followed by drip and sprinkler. Better irrigation access to farmers in the study area could help them to take advantage of the encouragement given in the project to high biomass cultivation.

4.7 Cropping Pattern in Madhya Pradesh

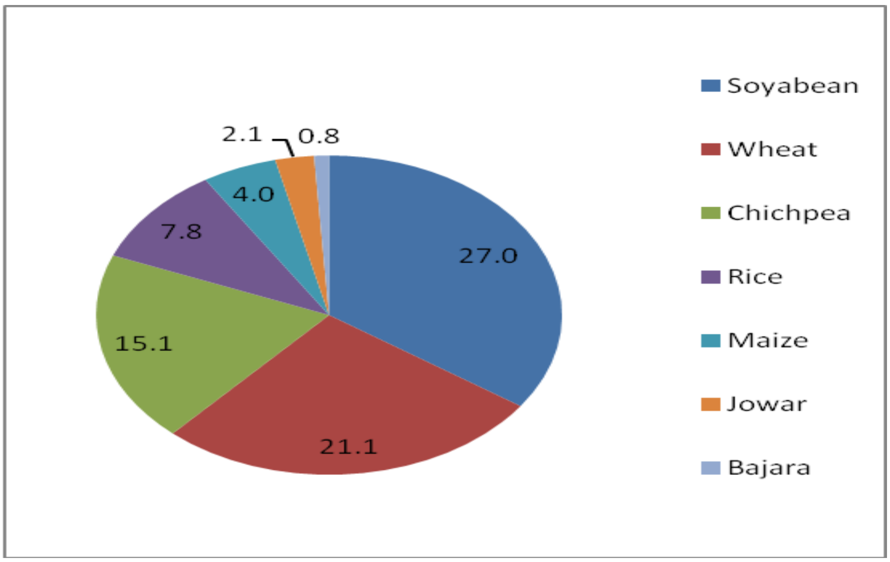
Gross cropping area of various crops in Madhya Pradesh clearly indicate that jowar and bajra occupy 2.1 per cent and 0.8 per cent respectively (see figure 4.4). Soya bean (27 per cent) occupies the major area, followed by wheat (21.1per cent) and chick pea (15.1per cent). Contrary to the state-level picture, the study sites of this baseline survey has considerable area under sorghum and pearl millet and interestingly, soya bean did not spread in the study villages.

Figure 4.3: Area under different sources of irrigation for sampled plots in the study areaduring 2013 (in acres)



Source: Field Survey

Figure 4.4: Percentage of area under cultivation of major crops to the gross cropped area in MP in 2010



Source: Field Survey

4.8 Cropping System

Farmers of drylands have developed diversified cropping systems to ensure that the most essential natural elements such as sunlight, wind, rainfall and soil are optimally utilised throughout the year. Crops that were developed over centuries were specifically bred to suit the changes in the rainfall pattern from year to year. The short and long duration varieties, water tolerant and drought resistant varieties, etc., that were developed were the result of this careful planning over centuries by farming communities. Inter cropping, mixed cropping, relay cropping and multi-tiered cropping were the strategies adopted by the sample farmers and were highly relevant. By doing so, the farmers have balanced food and cash crops, along with the fodder needs of their animals and simultaneously managed the fertility of their marginal soils. An effort was made to find out the cropping pattern in the study area.

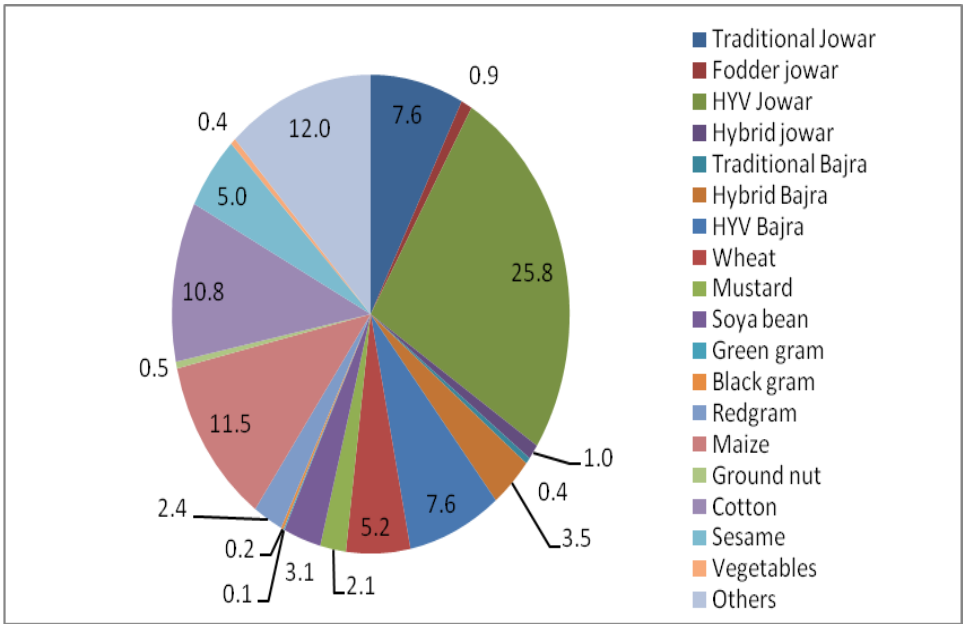
Table 4.9: Distribution of area under various cropping systems in sampled plots during 2012-13 (in acres)

Village name	Mono cropping	Intercropping	Mixed cropping	Grand Total
Nagada	313.0	0.0	0.0	313.0
Sunvani Mahankal	123.0	150.0	6.0	279.0
Nagziri	526.75	29.75	0.0	556.50
Rupheda	98.5	57.5	0.0	156.0
Baraha	313.5	0.0	0.0	313.50
Bijoli	144.58	0.0	0.0	144.58
Daheli	112.0	0.0	0.0	112.0
Jakara	353.50	0.0	0.0	353.50
Nahar Donki	164.8	24.5	3.0	192.30
Ummed garh	334.12	7.25	0.0	341.37
Grand Total	**2483.75**	**269.0**	**9.0**	**2761.75**

Source: Field Survey

It can be seen from table 4.9 that monocropping is predominant in the sample plots with an area of 2483.50 acres, followed by intercropping (269 acres). Mixed cropping is observed to be negligible (9 acres). This could be due to the rigorous campaign by the agricultural universities, private companies, and agricultural extension systems regarding the advocating of monocropping. One of the reasons for monocropping was to facilitate easy application of inorganic fertilisers, pesticides and weedicides. Another reason for the reduction in agro-biodiversity was the lack of easy access to labour during different times of a season, when these diverse crops get ready for harvest; and also market influence. A large number of farmers, especially the women, have been nurturing the agro-biodiversity and soil fertility without any support from the government (Reddy 2009). Figure 4.5 shows that jowar (around 35%) accounts for the largest share of crop that is being cultivated among the respondent households, followed by Bajra (11.5%). Even among these crops, it is the high-yielding varieties that occupy the largest share among the respondent households. This depicts the importance of these two crops in the study villages and more so importantly among the households in them.

Figure 4.5: Distribution of sampled household lands under various crops in the study area during Kharif 2012-13



Source: Field Survey

Table 4.10 indicates that the area cultivated by the sampled farmers is more during kharif (1164.45 acres) followed by rabi (626.23 acres) and summer (26.5 acres). The major crops cultivated in rabi are wheat and mustard.

Table 4.10: Total cultivated area of sampled households in different seasons during the year 2012-13 (Percent)

Village name	Kharif area	Rabi area	Summer area	Total land in acres
Nagada	12.88(150)	16.53(103.5)	13.20(3.5)	14.14(257)
Sunvani Mahankal	4.25 (49.5)	11.74(73.5)	86.80(23)	8.03(146)
Nagziri	23.64 (275.25)	0.64(4)	0.0(0)	15.37(279.25)
Rupheda	5.15(60)	1.44(9)	0.0(0)	3.80(69)
Baraha	16.14(188)	6.23(39)	0.0(0)	12.50(227)
Bijoli	6.14(71.5)	8.70(54.5)	0.0(0)	6.93(126)
Daheli	2.83(33)	8.62 (54)	0.0(0)	4.79(87)
Jakara	18.55(216)	24.27(152)	0.0(0)	20.25(368)
Nahar Donki	3.91(45.5)	5.98(37.5)	0.0(0)	4.57(83)
Ummed garh	6.50(75.7)	15.84(99.23)	0.0(0)	9.62(174.93)
Grand Total	**100.00(1164.45)**	**100.00(626.23)**	**100.00(26.5)**	**100.00(1817.18)**

Source: Field Survey

Note: Figures in the parentheses are the actual number of acres

It can be seen from tables 4.11 and 4.12 that varietal diversity exists in the case of both jowar and bajra. High-yielding varieties occupy a major area in case of both crops. During kharif (see table 4.11), the major area of the sampled households was under HYV jowar (253.12 acres) followed by maize (112.75 acres) and cotton (106 acres). Interestingly, the height of some of the traditional sorghum varieties grown by farmers is at least 12 feet and the price it fetches in the open market is Rs.2500 per quintal. Farmers perceive that traditional white sorghum fetches a better market price. Interestingly, unlike the state's scenario, soya bean is cultivated in a very less area, indicating that it has still not replaced the cultivation of sorghum and pearl millet in the sampled villages. This is due to the fodder requirement of the region due to its strong milk economy. Similar to the kharif season, crop diversity is observed to be prevalent during the rabi season too (see table 4.12). However, it is observed to be dominated by wheat (325.27 acres) and mustard (153.07 acres).

4.9 Livestock:

Livestock and farming are inseparable. Cattle provide draught power for agricultural operations and organic manure for maintaining soil fertility. Livestock also provide cash to many resource-poor farmers during critical times, for meeting their health and food

Table4.11: Village-wise distribution of sampled household lands under various crops in the study area during Kharif 2012-13 (In acres)

Crop name	Nagada	Chinvani	Nagziri	Rupkheda	Baraha	Bijoli	Daheli	Jakhara	Nahar Donki	Ummedgad	Crop-wise Total area
Traditional Jowar	2	18	21	4	0	3.5	7.5	17	1.25	0	74.25
Fodder jowar	0	1	3	4	0	0	0	0	0	0.75	8.75
HYV Jowar	54.5	11.5	70.5	0	3.5	27.5	2.5	74	4.85	4.27	253.12
Hybrid jowar	0	0	0	0	1	0	5	1.5	0	2.5	10
Traditional Bajra	0	0	0	0	0	0	1	2.5	0	0.75	4.25
Hybrid Bajra	0	0	0	0	24	2.25	6.5	0	1.25	0.0	34
HYV Bajra	0	0	0	0	2.5	0	4.5	4.25	30.37	33.25	74.87
Wheat	34.5	16.5	0	0	0	0	0	0	0	0	51
Mustard	0	0	0	0	0	2.5	0	0	0	18	20.5
Soya bean	14	2	9	0	5	0	0	0	0	0	30
Green gram	0	0	1	0	0	0	0	0	0	0	1
Black gram	0	0	0	0	0	0	0	0	2	0	2
Redgram	0	0	3	0	0	1.5	0	0	9.62	9.6	23.72
Maize	0	0.5	82.75	26	3.5	0	0	0	0	0	112.75
Groundnut	0	0	4	0	0	0	0	0	0.5	0	4.5
Cotton	0	0	76.5	26	3.5	0	0	0	0	0	106
Sesame	0	0	0	0	41.5	7.5	0	0	0	0	49
Vegetables	0	0	1	0	0	0	0	0	0	3.25	4.25
Others	0	0	2	0	41.5	14	15	0	34.2	10.6	117.3
Village wise total area.	**105**	**49.5**	**273.75**	**60**	**126**	**58.75**	**42**	**99.25**	**84.04**	**82.97**	**981.26**

Source: Field Survey

Table 4.12: Village-wise distribution of sampled household lands under various crops in the study area during rabi 2012-13 (In acres)

Crop name	Nagada	Chinvani	Nagziri	Rupkheda	Baraha	Bijoli	Daheli	Jakhara	Nahar Donki	Ummedgad	Crop-wise Total Area
Traditional Jowar	27	13.5	1	0	0	0	0	0	0	0.75	42.25
Fodder Jowar	0	0.5	3	0	0	0	0	0	0	0	3.5
HYV Jowar	22.50	2	0	0	0	1	0	0	0	0	25.5
Hybrid Jowar	0	0	0	0	0	0	0	0	0	3	1.5
Traditional Bajra	0	0	0	0	0	0	0	5	0	0	5
Hybrid Bajra	0	0	0	0	0	0	0	0	1.25	0	1.25
Wheat	46	47	0.75	6.5	16.5	32.5	26	63.5	28.25	58.27	325.27
Mustard	0	0	0	0	9	11	29.5	60	12	31.57	153.07
Soya bean	4	8	0	0	0	0	0	0	0	0	12
Redgram	4	2.5	0	0	0	0	0	0	0	0	6.5
Chick pea	0	0	0	2.5	0	10	15.5	1	0	0	29
Vegetables	0	0	3.75	0	0	7.5	12	0	1	3.12	27.37
Others	0	0	0	0	0	0	0	0	0	4.5	4.5
Village wise total area	**103.5**	**73.5**	**8.5**	**9**	**25.5**	**62**	**83**	**129.5**	**42.5**	**101.21**	**636.71**

Source: Field Survey

needs. Farm yard manure provided by the livestock has always been one of the principal means of replenishing soil losses in dryland regions. This manure is a major source of food for diverse soil biota which play a key role in soil productivity. The depletion of soil organic matter leads to deterioration in soil structure, reduced capacity to retain soil moisture and nutrients, and reduced microbiological activity (Reddy 2011). Table 4.13 indicates that though the study villages are predominantly agrarian in nature cultivating mainly wheat, jowar, bajra, soya bean and mustard, a substantial amount of their economy is also dependent on the rearing of livestock. Without livestock, dryland farming would not be possible. It is observed that most of the sampled households own buffaloes followed by cows and bullocks. Especially, the bullock population is coming down more with large farmers. The reasons are reduced farm size, increased mechanization, declining area under common lands, and changing patterns in labour availability (Conroy *et al.* 2001). Another reason is that earlier children from SC and BC communities, who worked for the landlords, are now going to school due to the awareness created by voluntary organizations and the emphasis given by the government on primary education.

Table 4.13: Total number of livestock owned by sampled households in the study villages during 2012-13

Village name	Buffalo	Bullock	Cow	Goat	Others	Grand Total
Nagada	19	1	8	0	6	34
Sunvani Mahankal	33	5	34	0	36	108
Nagziri	19	50	33	0	0	102
Rupheda	6	24	11	0	0	41
Baraha	54	0	0	0	0	54
Bijoli	89	0	7	12	0	108
Daheli	71	1	3	0	0	75
Jakara	123	0	4	0	2	129
Nahar Donki	57	0	2	2	0	61
Ummed garh	114	0	13	1	0	128
Grand Total	**585**	**81**	**115**	**15**	**44**	**840**

Source: Field survey

The livestock not only assists the households in the traditional agricultural activities but also provides a substantial amount of income source as the villagers supply milk to the nearby towns. It is important to note here that the traditional cultivation of bajra and jowar, the two main crops intended for bio-fuels in our study, are traditionally the major fodder sources for the livestock in the villages. It is in this context that we need to look at the viability of cultivation of food/fodder crops for large scale bio-fuel in the context of traditional and agrarian-based economies like India in general and in MP in particular.

An effort was made to understand the dependence of livestock-owning sampled households on various kinds of grazing areas for meeting the fodder requirements of their livestock. It was evident from table 4.14 that the animals are mostly predominantly grazed in lands owned by the households (42.5%), followed by stall feeding (36%). It is also observed that access to forest (4.5%) and CPRs (4.5%) has come down as compared to earlier times.

Table 4.14: Details of animal grazing areas used by sampled households during 2012-13 in the study area

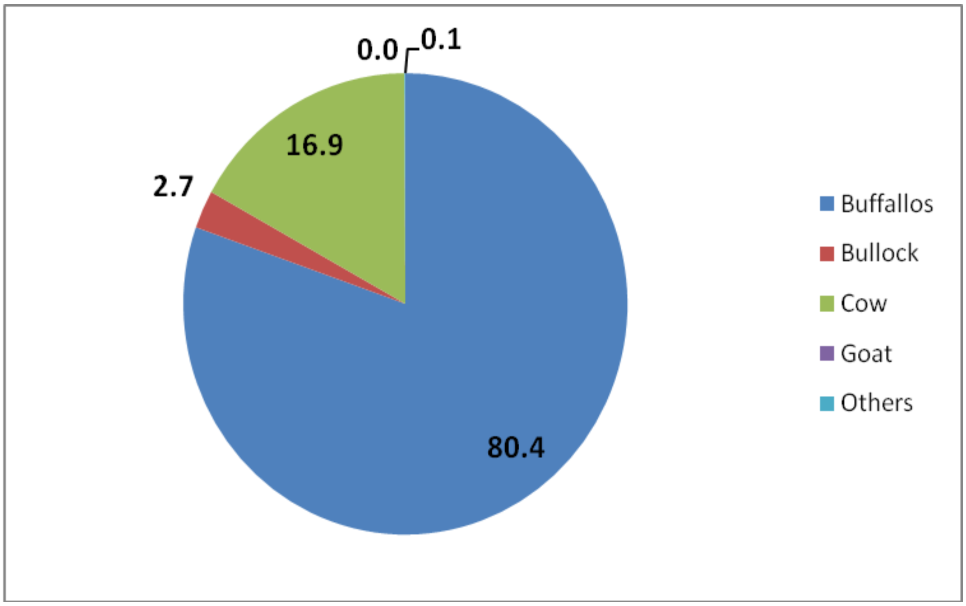
Village name	Stall feeding	Own lands	Private lands	Forest area	CPRs	Others	Total (N=247)
Nagada	57.1 (8)	21.4 (3)	7.1 (1)	14.3 (2)	0.0(0)	0.0(0)	100.0 (14)
Sunvani Mahankal	31.2 (5)	43.8 (70)	18.8 (3)	0.0(0)	0.0(0)	6.2 (1)	100.0 (16)
Nagziri	0.0(0)	48.5 (16)	27.3 (9)	9.1 (3)	0.0(0)	15.2 (5)	100.0 (33)
Rupheda	28.6 (4)	57.1(8)	7.1 (1)	7.1 (1)	0.0(0)	0.0(0)	100.0 (14)
Baraha	25.0 (5)	25.0 (5)	0.0(0)	5.0 (1)	45.0 (9)	0.0(0)	100.0 (20)
Bijoli	33.3 (7)	47.6 (10)	9.5(2)	0.0(0)	9.5 (2)	0.0(0)	100.0 (21)
Daheli	35.3 (6)	58.8 (10)	0.0(0)	5.9 (1)	0.0(0)	0.0(0)	100.0 (17)
Jakara	21.6 (8)	67.6 (25)	2.7 (1)	5.4 (2)	0.0(0)	2.7 (1)	100.0 (37)
Nahar Donki	63.6 (14)	9.1 (2)	27.3 (6)	0.0(0)	0.0(0)	0.0(0)	100.0 (22)
Ummed garh	60.4 (32)	35.8 (19)	0.0(0)	1.9 (1)	0.0(0)	1.9 (1)	100.0 (53)
Total	**36.0 (89)**	**42.5 (105)**	**9.3 (23)**	**4.5 (11)**	**4.5 (11)**	**3.2 (8)**	**100.0** (247)

Source: Field Survey

Note: The figures in the parentheses are actual number of households.

It can be seen from figure 4.6 that the sampled households derived their major income (80.4%) from buffaloes, followed by cows (16.9%) indicating that the study area has strong milk economy. Hence is the observed predominance of jowar and bajra in the region as they take care of the fodder needs of the milch animals. As seen from table 4.14, bullocks were present in only three villages Sunvani Mahankal, Nagzari and Rupheda and hence lesser income from them in the study area.

Fig. 4.6: Total income derived from the livestock in sample villages (INR)



Source: Field Survey

4.10 Indebtedness

This variable was operationalized as the amount of outstanding loan of a farmer from the loan taken from various sources during the years 2011-12 and 2012-13. They were categorized into 5 groups as indebtedness ranging between less than Rs.30000, Rs.30001-50000, Rs.50001 to 70000, and indebtedness above Rs.70001.

From table 4.15, it is evident that among the total sample farmers, the majority (58.6%) had not taken any loan. This is followed by indebtedness above Rs70000 and loans ranging between Rs.50001-70000. Amongthose who accessed loans, the primary purpose of loan is observed to be for the purchase of agricultural inputs (21.9%) followed by 6.9 percent for consumption purpose and irrigation (6%). It is observed that increase in costs of inputs and decrease in profits from farming is pushing farmers towards debt. It is a good sign to see that majority did not access any credit for farming (see table 4.16). It is interesting to observe that majority of the sampled households (23.1%) are taking credit from fertiliser and pesticide dealers, followed by money lenders (11.7%). A large number of fertiliser and pesticide dealers are unaware of the basics of agriculture and are mostly driven by commercial interests. Since farmers are procuring these fertiliser and pesticide products from private dealers, by the end of the season, there would be a large amount of money due to the dealer. Hence, quite often, they are forced to sell off their produce to the very same dealer at a much cheaper rate than the existing market price. Financial exclusion in terms of access to credit from formal institutions is high for small and marginal farmers and some social groups (Dev, 2006). It is clear from table 4.16 that majority of the households used personal trust (17.7%) to access loans, followed by mortgage of patta pass books (15.3%). Nearly 15 per cent of the farmers are observed to access loans at a monthly interest rate of Rs.3, followed by 14.4 per cent at the rate of one rupee. It is also seen that out of the 138 households accessing loans only 20 households (14.4%) could repay the loan they have taken.

Table 4.15: Distribution of sample households according to their indebtedness (percentage) in 2012-13

Village name	Less than Rs.30000	Rs.30001-50000	Rs.50001-70000	Above Rs.70001	Not taken any loan	Total (N=333)
Nagada	11.8(2)	0.0(0)	23.5(4)	64.7(11)	0.0(0)	100.0(17)
Chinvani	27.8(5)	0.0(0)	22.2(4)	38.9(7)	11.1(2)	100.0(18)
Nagaziri	11.1(6)	1.9(1)	25.9(14)	27.8(15)	33.3(18)	100.0(54)
Rupkheda	20.0(3)	6.7(1)	40.0(6)	33.3(5)	0.0(0)	100.0(15)
Baraha	0.0(0)	0.0(0)	0.0(0)	0.0(0)	100.0(54)	100.0(54)
Bijoli	9.1(2)	0.0(0)	0.0(0)	0.0(0)	90.9(20)	100.0(22)
Daheli	17.6(3)	0.0(0)	0.0(0)	0.0(0)	82.4(14)	100.0(17)
Jakara	0.0(0)	0.0(0)	0.0(0)	0.0(0)	100.0(52)	100.0(52)
Nahar Donki	18.2(4)	4.5(1)	18.2(4)	13.6(3)	45.5(10)	100.0(22)
Ummed Garh	37.1(23)	4.8(3)	4.8(3)	12.9(8)	40.3(25)	100.0(62)
Total	**14.4(48)**	**1.8(6)**	**10.5(35)**	**14.7(49)**	**58.6(195)**	**100.0(333)**

Source: Field survey

4.11 Cost of Cultivation:

Table 4.17 presents the crop economics that are prevalent in the study area of Madhya Pradesh. It could be seen from table that traditional jowar and high-yielding varieties of jowar were doing well in the year 2012-13, as compared with hybrid jowar. During the years of lesser rainfall the hybrids do not perform well as can be seen in table 4.17. Moreover, hybrid jowar attracts certain pests and diseases, thereby affecting the yield and income. Interestingly, in the case of bajra, the hybrid variety was doing extremely well with a good per acre net income (Rs.10748), followed by traditional bajra (Rs.3644). Furthermore, hybrid jowar and HYV bajra showed a negative income during the year

2012-13. Though there was lesser area of soya bean, it was doing very well on the economic front with a per acre income of Rs.15724. Despite being cultivated in a major area during rabi, wheat is observed to give a moderate income of Rs.4618/acre to the sampled households. As seen from table 4.17, cultivation of mustard during rabi gave rich returns to the sampled farmers. Similarly, red gram, chick pea and groundnut also give a good per acre net return. On the other hand, green gram's net returns are observed to be negative as the crop had badly suffered due to less rain during the initial stages of the crop season. Similarly, cultivation of cotton crop also led to losses due to heavy input costs and lesser yields due to pest incidence and poor performance of bt cotton under unfavourable climatic conditions.

Table 4.16: Credit details of sampled households during 2011-12 and 2012-13

Source of Loan						(N=333)
Not taken any loan	Commercial bank	Co-operative bank	Money lender	Fertilizer dealer	Others	Grand Total
58.6	3.3	2.4	11.7	23.1	0.9	100.0
(195)	(11)	(8)	(39)	(77)	(3)	(333)
Purpose of Loan						
Agricultural inputs	**Consumption**	**Irrigation**	**Health**	**Others**	**Not taken any loan**	**Total**
21.9	6.9	.6	5.4	6.37	58.6	100.0
(73)	(23)	(2)	(18)	(22)	(195)	(333)
Mortgaged Item						
	Patta pass book	**Gold**	**Trust**	**Promisory note**	**Not taken any loan**	**Total**
	15.3	3.3	17.7	4.8	58.6	100.0
	(51)	(11)	(59)	(16)	(195)	(333)
Interest Rate per Rs100 as loan/Month						
	Not taken any loan	**Rs1**	**Rs.2**	**Rs.3**	**Rs.4 and above**	**Total**
	58.6	14.4	6.9	15.0	5.1	100.0
	(195)	(48)	(23)	(5)	(17)	(333)
Loan Outstanding						
	Less than Rs.30000	Rs.30001-50000	Rs.50001-70000	Above Rs.70001	Not taken any loan	Total
	19.5	3.0	4.2	8.7	64.6	100.0
	(65)	(10)	(14)	(29)	(215)	(333)

Source: Field Survey

Table 4.17: Average cost of cultivation of major crops in the study area during the year 2012-13 (in Rupees/Acre)

Crop	Total Cost	Total Income	Net Income
Traditional Jowar	14504	18791	4287
Fodder Jowar	13438	15616	2178
HYV Jowar	12070	18745	6675
Hybrid Jowar	12846	10137	-2709
Traditional Bajra	12216	15860	3644
HYV Bajra	12248	12105	-143
Hybrid Bajra	14074	25452	10748
Wheat	23242	27860	4618
Mustard	14020	34228	20208
Soya bean	26962	42686	15724
Green gram	14366	7000	-7366
Red gram	9066	23941	14875
Chick pea	16670	33106	16436
Maize	14648	20358	5710
Ground nut	19234	32548	13314
Cotton	37616	31395	-6221
Til	8328	7974	-354

Source: Field Survey

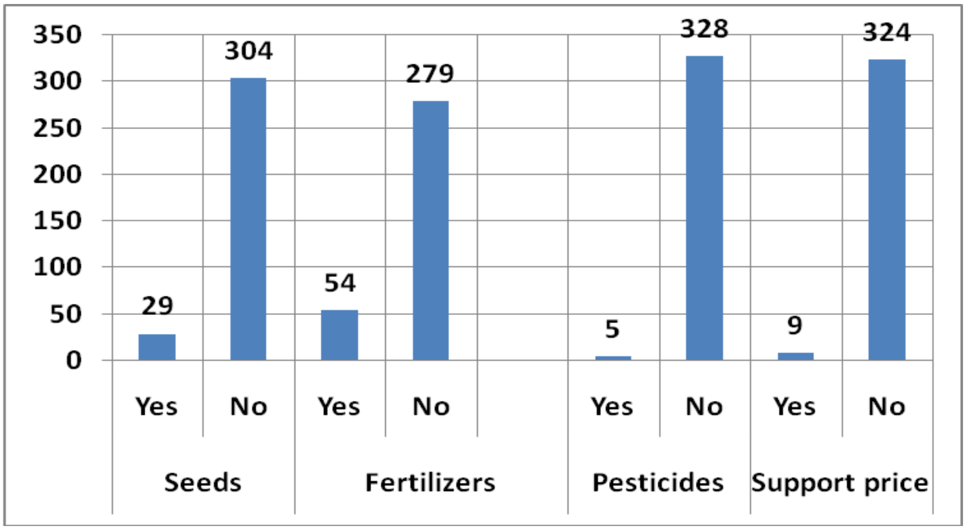
Table 4.17 clearly indicates that the high biomass jowar and bajra varieties being promoted in the Indo-US JCERDC biofuel project should be more fetching than the existing cultivars of these staple food crops; they should also have a comparative advantage simultaneously with other crops such as the soya bean, wheat and mustard. Otherwise the farmers might not be inclined to adopt these varieties for biofuels production.

4.12 Sorghum (Jowar) / Pearl Millet (Bajra) Crops and their Subsidy

The present study also tried to understand the kind of subsidy the staple food crops get in the region. Responses of the sample households were taken to understand the satisfaction regarding the subsidy support they get for components such as seed fertilizers and pesticides. Their responses regarding the satisfaction for the Minimum Support

Price (MSP) for jowar and bajra were also elicited. It can be observed from figure 4.7 that very less subsidy was available for the cultivation of these food crops with regard to seeds and fertilizers and negligible support form pesticides. Similarly, a very negligible percentage of the sampled households was happy with the kind of MSP given by the government for these staple food crops. It is crucial for the sorghum and millet sector to be supported by strong government policies and programmes for food, fodder and better nutrition through value addition and demand creation (Nagarj *et al.*, 2013).

Fig.4.7: Distribution of households according to their responses regarding subsidy availability and MSP for jowar during the year 2013

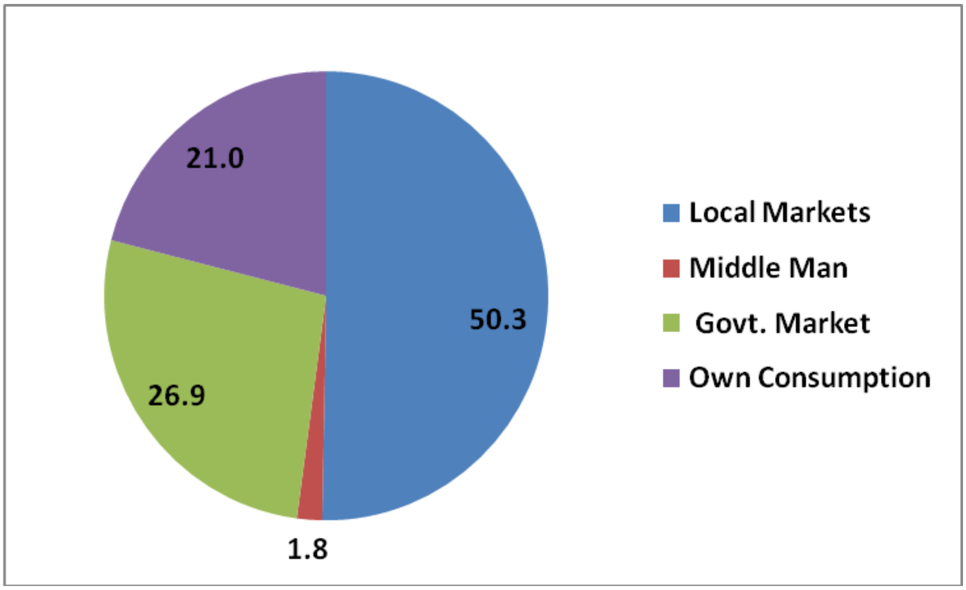


Source: Field Survey

4.13 Water Pollution:

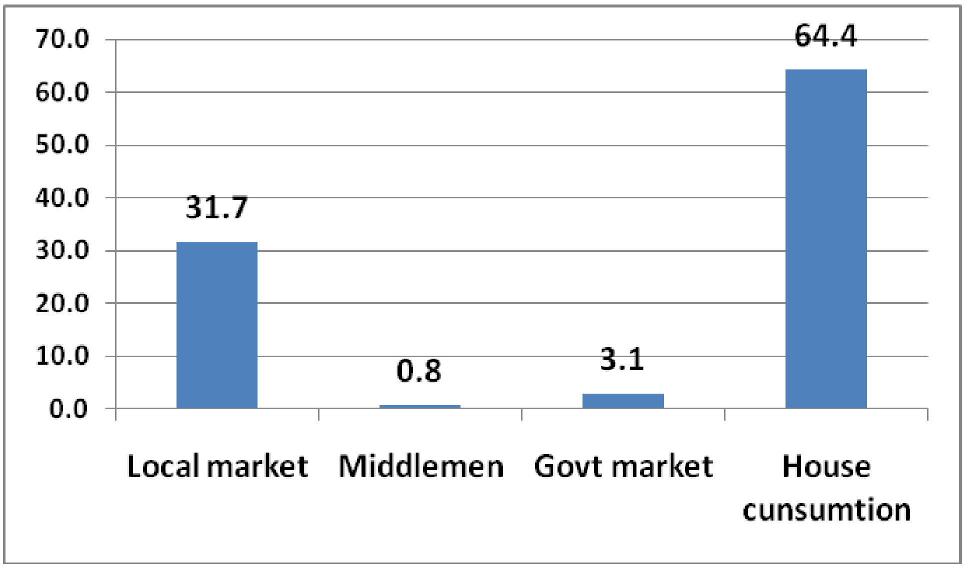
The study also looked at the farmers' perception regarding the environmental pollution caused by the use of pesticides and fertilizers in general and cultivation of jowar and bajra in particular. Table 4.18 indicates that only 13.81 per cent of the households reported that there was pollution of water bodies due to usage of fertilizers and pesticides in crop cultivation while 86.19 per cent reported no pollution. In Sunvani Mahankal Village, all the sampled households reported pollution due to usage of fertilizers and pesticides whereas in Rupheda and Bahara villages, none of the sampled households reported pollution. A further enquiry was conducted to understand the number of bodies that are being affected in the study villages. Figure 4.10 shows that nearly 10.21 per cent of the sampled households reported pollution of three water bodies in their village.

Fig.4.8: Distribution of households according to their response of marketing channels used for jowar grain



Source: Field Survey

Fig. 4.9: Distribution of households according to their response regarding marketing channels used for jowar fodder



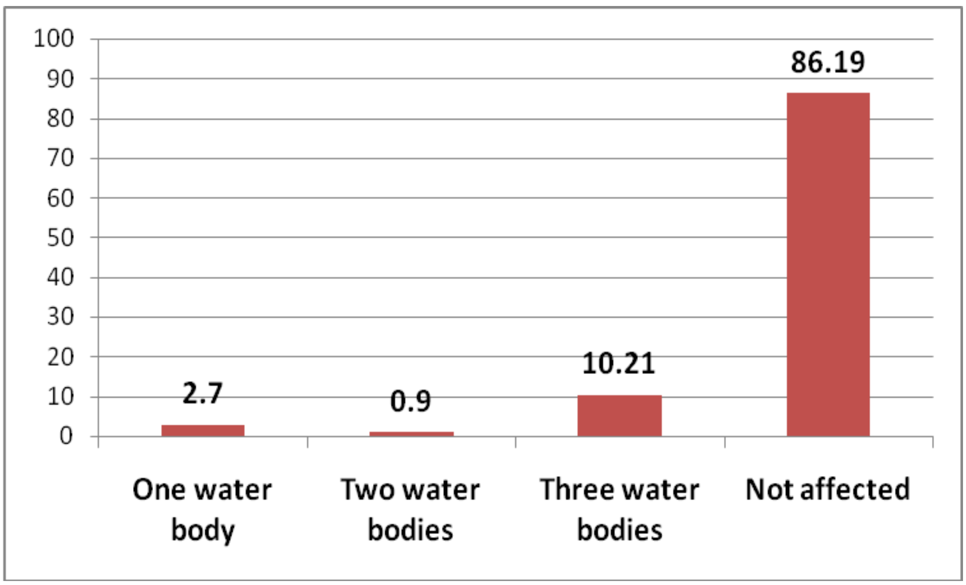
Source: Field Survey

Table 4.18: Response of sampled households with respect to water pollution due to pesticide and fertilizer applications

Village name	Yes	No	Grand Total
Nagada	82.35(14)	17.65(3)	100.00(17)
Sunvani Mahankal	100.00(18)	0.00(0)	100.00(18)
Nagziri	1.85(1)	98.15(53)	100.00(54)
Rupheda	0.00(0)	100.00(15)	100.00(15)
Baraha	0.00(0)	100.00(54)	100.00(54)
Bijoli	9.09(2)	90.91(20)	100.00(22)
Daheli	5.88(1)	94.12(16)	100.00(17)
Jakara	3.85(2)	96.15(50)	100.00(52)
Nahar Donki	18.18(4)	81.82(18)	100.00(22)
Ummed garh	6.45(4)	93.55(58)	100.00(62)
Grand Total	**13.81(46)**	**86.19(287)**	**100.00(333)**

Source: Field survey

Fig 4.10: Response of sampled households regarding the number of water bodies Polluted due to pesticide and fertilizer applications



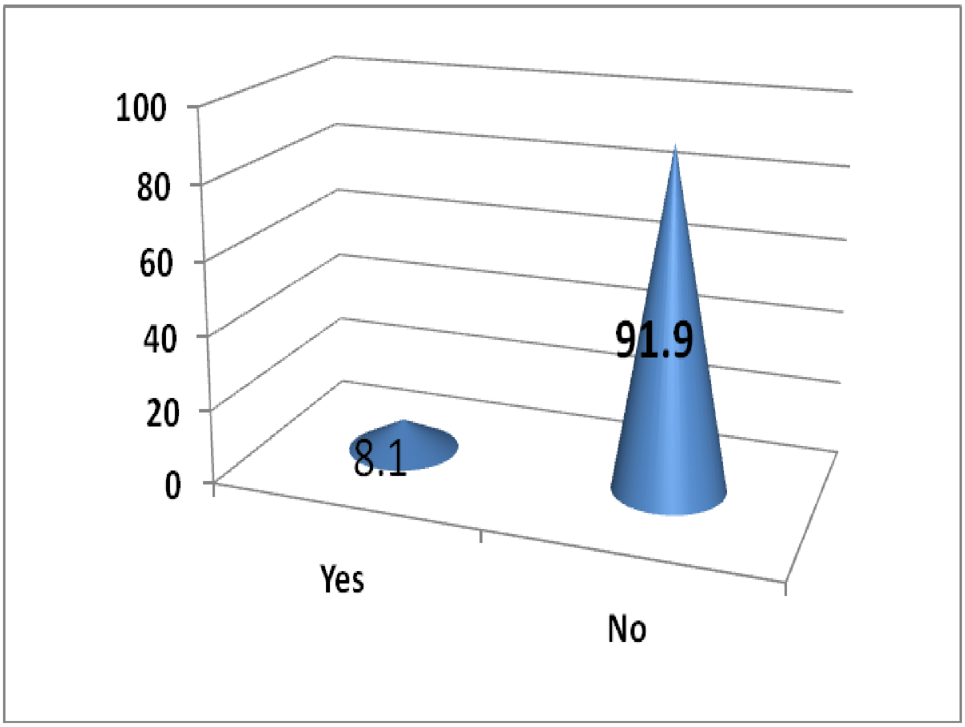
Source: Field Survey

4.14 Awareness on Biofuels:

As noted in the literature, the lifecycle of biofuel production from the cultivation of biofuel crops to the final consumption is a highly complex and complicated process with high inter-linkages between different sections of the economy. Hence, a proper understanding of the process is necessary. However, the initial analysis of our primary study shows that awareness among farm households is almost negligible, which might further complicate the large scale production of these crops.

Farmers' perception regarding biofuels and their cultivation was also assessed in the present study. Figure 4.11 indicates that 91.9 percent of the sampled households did not have any awareness about the biofuels. Continuing the probe further, farmers were asked whether they have any idea about the production of biofuels from agricultural crops such as jowar and bajra to which they responded negatively nearly 95 per cent of the farmers had no idea about this. Further, they were asked whether this kind of biofuel production from jowar and bajra is desirable. Responding to this, 79.88 per cent said yes and 20.12 per cent said no.

Fig 4.11: Awareness of sampled households with respect to biofuels

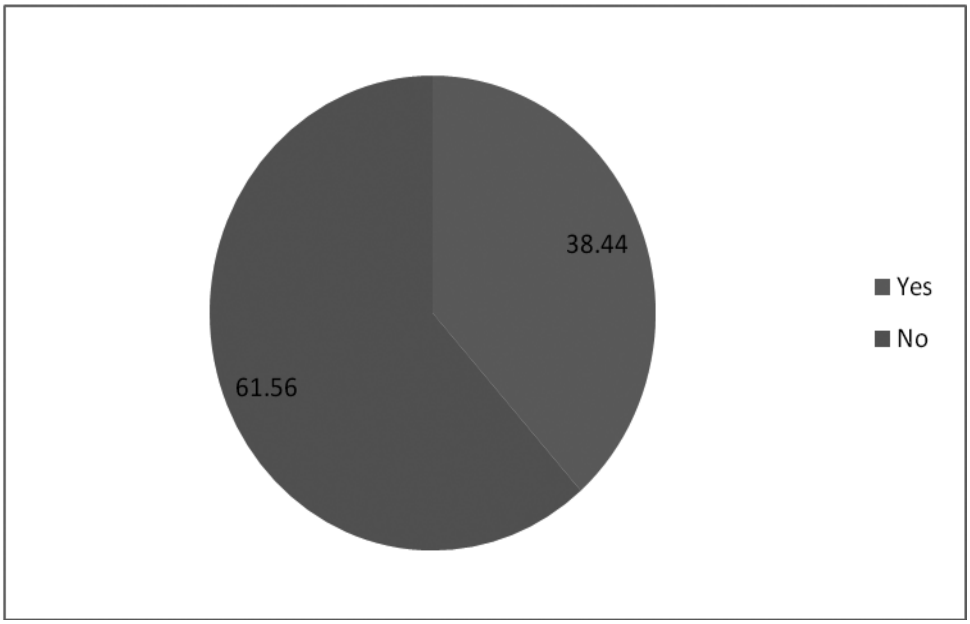


Source: Field Survey

4.15 Impact on Food Security

Continuing the investigation further, information was elicited regarding possible shortage of food grains due to diversion of jowar and bajra for biofuel cultivation. As the probing got deeper, it was interesting to observe that 38.44 per cent of the households agreed that it will result in shortage of food grains while 61.56 per cent did not percieve a reduction in the food supply.

Fig. 4.12: Farmers' perception of possible shortage of food grains due to diversion of jowar and bajra for biofuel cultivation



Source: Field survey

Majority of the respondents felt that there would not be any impact on food security, citing the reason that they would supplement jowar/bajra either by procuring from fair price shops or from retail markets. Out of the 128 households which felt that there will be a reduction in food grains, 66.40 per cent felt that such reduction in grains will impact the household food security, while 33.60 per cent did not agree. Development of biofuels to meet the requirements of the transport sector can bring about changes in the land use pattern of the country and could threaten food security and other agrarian supplies (Singhal and Sengupta, 2012).

4.16 Impact on Fodder Security

The potential diversion or displacement of food crops is also considered to be a serious problem. Though the initial analysis of our field shows that the impact might not be much regarding food grain security, there is a considerable amount of apprehension on its potential impact on fodder security. It is evident from table 4.19 that even before the cultivation of these crops for biofuels production, a majority of the households (51.96%) believes that use of these crops will affect the fodder security of their animals.

Table 4.19: Village-wise response of farmers regarding the impact of use of jowar/ bajra for biofuel production on fodder security

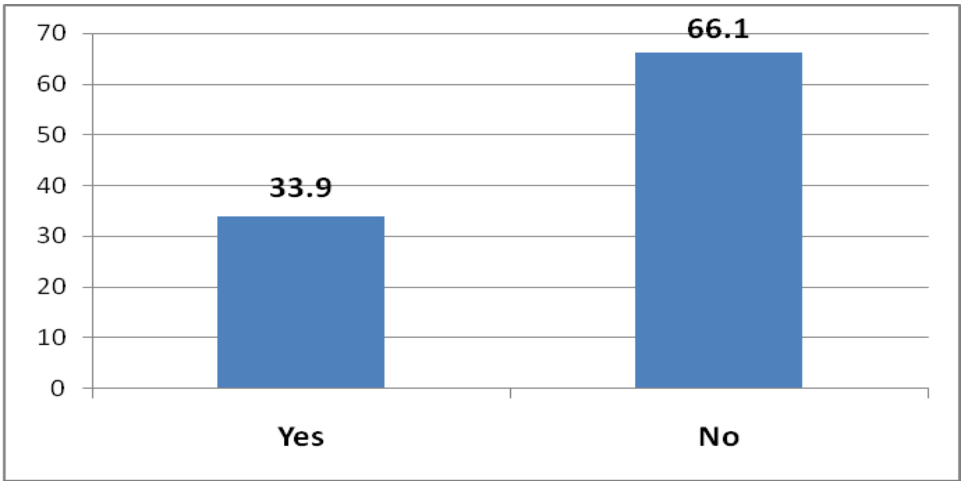
Village name	Yes	No	Total
Nagada	47.06 (8)	52.94(9)	100.0(17)
Chinvani	55.6(10)	44.4(8)	100.0(18)
Nagaziri	61.1(33)	38.9(21)	100.0(54)
Rupkheda	46.7(7)	53.3(8)	100.0(15)
Baraha	37.03(20)	62.96(34)	100.0(54)
Bijoli	31.8(7)	68.2(15)	100.0(22)
Dahel	52.9(9)	47.1(8)	100.0(17)
Jakara	19.2(10)	80.8(42)	100.0(52)
Nahar Donki	100.0(22)	0.0(0)	100.0(22)
Ummed Garh	75.8(47)	24.2(15)	100.0(62)
Total	**51.96(173)**	**48.04(160)**	**100.0(333)**

Source: Field Survey

On the other hand, 48.04 per cent of the sampled households perceived that there won't be any impact on fodder security. It was very interesting to see that across all study villages of the five districts, there were a few households which did perceive that there would be fodder insecurity in the event of cultivation of these crops for biofuels production (see table 4.19).

A further investigation was conducted to understand whether the diversion of fodder/ biomass for biofuel production will affect the milk economy of the region. Nearly 33.9 per cent of the sampled households perceived that it will affect the milk economy, whereas 66.1 per cent responded negatively (see fig.4.13).

Fig.4.13: Impact of diversion of fodder for biofuel production on milk economy

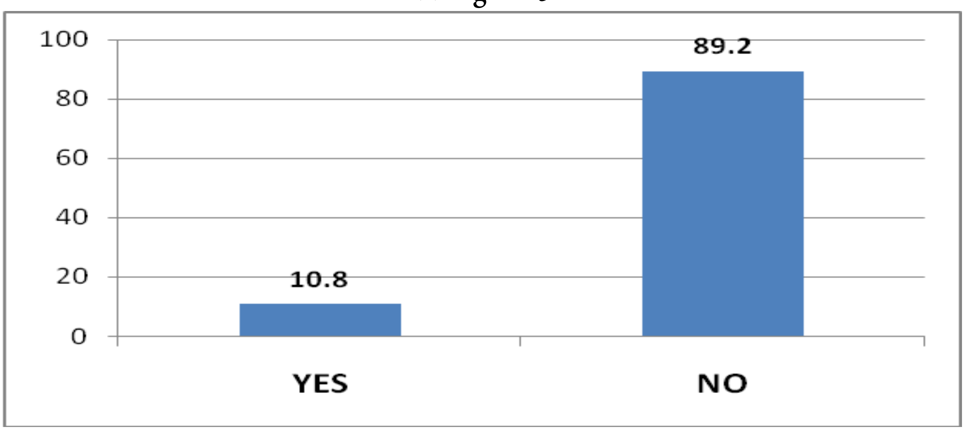


Source: Field Survey

4.17 Migration:

Migration was another important issue that the baseline study observed in the study areas. It was interesting to note that during 2013 only 10.8 per cent of the sampled households reported migration of their family members every year while 89.2 per cent did not migrate at all (see fig 4.14). Those who migrated usually went to the nearest towns for a couple of months in a year Bbecause, due to the vibrant agrarian and milk economy, people found work in their respective villages. Moreover, households with livestock cannot easily migrate, ignoring the fodder and drinking water needs of their livestock.

Fig. 4.14: Response of sampled households regarding migration of family members during 2013



4.2 Conclusion

Achieving energy security in the country through alternate methods is an important area being focused upon by the Indian policy makers. However, any attempt to promote the use of major staple food crops such as jowar and bajra for biofuel production has a long-lasting impact on the food, fodder and nutritional security of millions of people and livestock in India. Cultivation of high biomass jowar and bajra varieties on a large scale could pose a serious threat to the existing rich diversity in these crops. Hence, even for trying out these crops at research level, it is essential to have a dialogue with the farmers of drylands where these two crops are predominantly grown. The voice of small and marginal farmers and women should be heard before moving further to utilize these crops for biofuel production. More importantly, we should learn from our earlier experiences of jatropoha cultivation (Montobio and Lele, 2010; Singhal and Sengupta, 2012).

Hence, large-scale biofuel production is not an alternative to the current use of oil and is not even an advisable option to cover a significant fraction of it (Giampietro *et al.*, 1997). The production of feed stocks for biofuels would put additional pressure on agricultural resources such as land and water. Therefore, it is quite important that policies, plans and strategies for energy security do not conflict with other aspects of critical national importance such as food security.

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