SCIENCES AND CULTURES: PLURALIST NARRATIVES OF BIOFUELS IN INDIA

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

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JANUARY 2020

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DECLARATION

I hereby declare that the thesis entitled **"Sciences and Cultures: Pluralist Narratives of Biofuels in India"** is the result of investigation carried out by me at the Department of Humanities and Social Sciences, Indian Institute of Technology Guwahati, under the supervision of Dr. Sambit Mallick. The work has not been submitted either in whole or in part to any other university/institution for a research degree.

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CERTIFICATE

This is to certify that Mr. Rahul Shukla has prepared the thesis entitled **"Sciences and Cultures: Pluralist Narratives of Biofuels in India"** for the degree of Doctor of Philosophy at the Indian Institute of Technology Guwahati. The work was carried out under my supervision and in strict conformity with the rules laid down either in whole or in part to any other university/institution for the purpose. It is the result of his investigation and has not been submitted either in whole or in part to any other university/institution for a research degree.

IIT Guwahati
January 2020

Sambit Mallick
Supervisor

Acknowledgments

This thesis has reached to conclusion with the generous support and unwavering faith of many individuals. While I express my sincere gratitude to all for their invaluable contributions, I would like mention a few of them here. First of all, I would like to thank my research supervisor Prof. Sambit Mallick for his unfailing faith in me. His timely response to my thesis drafts and astute observations has helped in improving thesis. He provided me with strength and motivation during the toughest phases of my research. Without his generous support, both academic and emotional, and encouragement completing this thesis would have been a very challenging task. I am thankful to him for his remarkable patience in trying times of completing this thesis.

I would like to thank my doctoral committee members Dr. Swamya Ray, Dr. Ngamjahao Kipgen and Dr. Bidisha Som for their critical engagement and suggestions pertinent to the study. I would also like to thank people of Godhi, Mangeli, Pendra, Devla and Gogunda village who welcomed me in their life and shared the details and different colours of it. I am also grateful to the organizations and scientists for giving time for the interviews.

I thank and acknowledge the support received from the IIT Guwahati and the department of HSS and its members Durga, Bandana, Parag, Rubul and Kanthai.

I would like to thank my friends Abhay, Ruby, Manmeet, Saket, Bantu, Ashwini and Krishnakant for being supportive throughout my field work and later they keep on encouraging me to complete my thesis. Jeetendra, Sangey, Savio, Avinash, Tulika, Ado, Halim my friends at IIT Guwahati campus motivated me during the entire academic and social engagement in the campus.

I show appreciation for my family members. At the end, I express my gratefulness my partner Ankita, for her support and patience.

Finally, while the credit goes to all, the mistake, if any, is mine.

Abstract

Biofuels have caught the attention of the world as a source of renewable energy which can provide energy security, advance rural development, mitigate climate change, and foster international trade. India developed the National Mission on Biodiesel (NMB) in 2003 as a rural development policy option to produce biodiesel from jatropha and promoted it as a pro-poor and pro-growth initiative, and subsequently in 2009, the Government of India introduced the National Policy on Biofuels (NPB) to widen the scope of the NMB. The study attempts to examine the emergence, trajectory, and consequences of the NMB to assess how the NMB worked as a test development policy programme in India.

The study locates the trajectory of an object, which has been constructed into an industrial crop from a bush of semi-arid regions. What are the epistemic practices adopted by various actors in this construction? How is such knowledge diffused from laboratory to farmland? Where does new cultivation get (the) space? And, then, it moves on to discussing the policymaking process in India, making reference to pluralist narratives in development policymaking and how it leads to blueprint development of biofuels. It traces the role of an actant (atropha) and various actors such as policymakers, bureaucrats, researchers, professionals from private companies and NGOs, farmers, and landless labourers involved in the biodiesel mission. In this process, the present study is an attempt to find the research gaps in existing literature.

The study is anchored in the discipline of Science, Technology and Society, particularly from Actor-Network Theory (ANT) and Social Construction of Technology (SCOT) to analyse the literature concerning the studies and discourses in scientific claim making and policy framing. The study provides the global and Indian experiences of biofuels. We discuss the rise of biofuels and biofuel policies world over and how many developed and developing countries have either formed or are introducing biofuel policies, mandates, and missions. We try to locate the emergence of jatropha in the backdrop of post-colonial development policies in India. We attempt to trace the genealogy of construction of wasteland in both colonial and post-colonial India. In turn,

we discuss the Indian biofuel policies and missions in the pretext of wasteland development.

We aim to capture the materiality and agency of jatropha, discursive nature of scientific claim-making in biofuel promotion or opposition, and in turn we move on to find the presence of sociotechnical system for biofuels in India. The study depicts the interaction between jatropha and the scientific community in the background of diverse ways in which research and development on jatropha is carried out in social, political and technological facets. An attempt is also made to understand the dialectic of resistance and accommodation mediated between jatropha and the scientist in the process of development of a biofuel feedstock. We argue that the development of variety and hybrid is employed in terms of accommodation from the scientific community to address the resistance presented by jatropha in while mediating with the elements of biophysical, domestication and disease resistance.

Further, we attempt to explore the impediments and risks involved in the cultivation of biofuels, particularly jatropha, from the perspective of the farming community. We attempt to juxtapose responses of the farming community and the scientific community against this backdrop: when jatropha reaches from the laboratories to the farmlands. The study reflects upon the national and local narratives supporting the development of biofuels and how these narratives played an important part in the emergence of local biofuel narratives across different states and in turn encouraged the hasty creation of biofuel policies, mandates, and missions. Here we attempt to respond on the question how the national biodiesel narratives while being influenced by the global narratives displayed regional characteristics specific to India's goals to produce biodiesel. Thereby, the study depicts the varying cultural associations, practices, and tacit meanings among the users in the field sites. In this process, the present study does not aim to make conclusions but to situate pluralist debates on biofuels in India.

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Abbreviations

ANT	Actor-Network Theory
BIS	Bureau of Indian Standards
CAPART	Council for the Advancement of People's Action and Rural Technology
CBDA	Chhattisgarh Biofuel Development Authority
CPCB	Central Pollution Control Board
CPRs	Common Property Resources
CREDA	Chhattisgarh Renewable Energy Development Agency
CSIR	Council of Scientific and Industrial Research
CSMCRI	Central Salt and Marine Chemicals Research Institute
DBT	Department of Biotechnology
DOLR	Department of Land Resources
DORD	Department of Rural Development
DRDO	Defense Research and Development Organisation
EBP	Ethanol Blending Programme
EGS	Employment Guarantee Scheme EU European Union
FAO	Food and Agricultural Organisation
GIBN	Global Integrated Biofuel Network
GoI	Government of India
FDA	Forest Department Agencies
GHG	Green House Gas
GIBN	Globally Integrated Biofuel Network
GoI	Government of India
HPCL	Hindustan Petroleum Corporation Limited
HSD	High Speed Diesel
IOCL	Indian Oil Corporation Limited
ICAR	Indian Council of Agricultural Research
ICAR	Indian Council of Agricultural Research
ICFRE	Indian Council of Forestry Research and the Environment
ICT	Information Communication Technology
IEA	International Energy Agency
IIP	Indian Institute of Petroleum
IIT	Indian Institute of Technology

IOC	Indian Oil Corporation
JFM	Joint Forestry Management
JNAU	Jawaharlal Nehru Agricultural University
KVIC	Khadi and Village Industries Commission
LCA	Life Cycle Assessment
MNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MNRES	Ministry of Non-Renewable Energy Sources
MoA	Ministry of Agriculture
MoEF	Ministry of Environment and Forest
MoPNG	Ministry of Petroleum and Natural Gas
MoRD	Ministry of Rural Development
NABARD	National Bank for Agriculture and Development
NBP	National Biofuel Policy
NCA	National Commission on Agriculture
NGO	Non-Governmental Organisations
NMB	National Mission on Biodiesel
NOVOD	National Oilseeds and Vegetable Oil Development Board
NPB	National Policy on Biofuels
NREGA	National Rural Employment Guarantee Act
NRSA	National Remote Sensing Agency
NWDB	National Wasteland Development Board
OECD	Organisation for Economic Co-operation and Development
OPP	Obligatory Passage Point
R&D	Research and Development
SCOT	Social Construction of Technology
SHG	Self Help Group
STS	Science, Technology and Society
SVO	Straight Vegetable Oil
TBO	Tree Borne Oilseed
TNAU	Tamil Nadu Agricultural University
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
VO	Voluntary Organisations
WB	World Bank

Chapter I

Introduction

1.1 Introduction

Biofuels have caught the attention of the world as a source of renewable energy which can provide energy security, advance rural development, mitigate climate change, and foster international trade. India developed the National Mission on Biodiesel (NMB) in 2003 as a rural development policy option to produce biodiesel from jatropha and promoted it as a pro-poor and pro-growth initiative, and subsequently in 2009, the Government of India introduced the National Policy on Biofuels (NPB) to widen the scope of the NMB. The study attempts to examine the emergence, trajectory, and consequences of the NMB to assess how the NMB worked as a test development policy programme in India. The study locates the trajectory of an object, which has been constructed into an industrial crop from a bush of semi-arid regions. What are the epistemic practices adopted by various actors in this construction? How is such knowledge diffused from laboratory to farmland? Where does new cultivation get (the) space? And, then, it moves on to discussing the policymaking process in India, making reference to pluralist narratives in development policymaking and how it leads to blueprint development of biofuels. It traces the role of an actant (atropha) and various actors such as policymakers, bureaucrats, researchers, professionals from private companies and NGOs, farmers, and landless labourers involved in the biodiesel mission. In this process, the present study is an attempt to find the research gaps in existing literature.

The study is anchored in the discipline of Science, Technology and Society, particularly from Actor-Network Theory (ANT) and Social Construction of Technology (SCOT) to analyse the literature concerning the studies and discourses in scientific claim making and policy framing. Hence this studies how development narratives are used to promote the biodiesel initiatives, how networks are created to establish the biofuels mission as a policy option and advocate its adoption, and in turn how the NMB progressed as a development initiative. As it draws from SCOT the discussion emphasises on the practices of a society adopting a technology / development initiative, the importance of users (scientists, policymakers,

farmers, labourers, representatives from the industry and NGOs), how users are represented, and in turn how the NMB has an influence on the people adopting it.

1.2 Review of Literature

1.2.1 Science, Technology and Society (STS) Perspectives through the Ages

STS is a discourse constructed in relation, and largely in opposition, to traditions of philosophy, history, and sociology of science that sought to codify and uphold science as an ideal model for liberal political order. STS as a project has been driven by doubts about the validity of the image of science (universalism, neutrality, impersonality, etc.) that underlay liberal model. Following a sustained intellectual attack on the epistemological, sociological, and historical underpinnings of the liberal model of science attention within STS is increasingly focused on the political implications of its critique (Thorpe 2008). STS focuses on reform or activism, critically addressing policy, governance, and develops sophisticated understanding of scientific and technical knowledge. It also tries to reform science and technology by holding aloft the banner of equality, welfare and environment (Sismondo 2011).

The history of STS can be incepted in 1936 with Mannheim's sociology of knowledge (Mannheim 2013[1936]), but various STS scholars take Thomas Kuhn's *The Structure of Scientific Revolutions* (2012[1962]) as a starting point for the standard history, which emphasized the communal basis of the solidity of scientific knowledge (ibid.). Since the 1960s and 1970s, the metaphor of "construction" became ubiquitous STS scholars that included artifacts, methods, materials, observations, phenomenon, classifications, institutions, interests, gender, histories and cultures within its expanding scope. This metaphor (social constructivism) provides three assumptions about science and technology: first, science and technology are importantly *social*; second, they are *active*; and third, the product of science and technology *are not themselves natural* (Latour and Woolgar 1979; Sismondo 1993; Hacking 1999).

The metaphor of construction, in its generic form, thus ties together much of STS: Kuhn's historiography of science; ethnographic interest in the stabilization of materials and knowledges; ANT's mandate to distribute the agency of technoscience widely; SCOT's observation of the interpretive flexibility of even the most straightforward of technologies (Sismondo 2011).

1.2.2 Actor-Network Theory (ANT)

By opting metaphor of construction and combining ANT and SCOT for theoretical framing, the study examines how the jatropha was introduced as a policy mission at the central level and in turn how it was introduced across the states. To answer this question, the study focuses on the role of actor-networks, policy-networks that play a key role in policymaking and in extending development projects. Policymaking occurs within specific social structures or through various 'structural apparatuses', including existing institutional arrangements or 'rules of the game' (Ostrom 1992; Scott 2013) and actor-networks; the rule of games is also referred to as policy communities, issue networks, or historically as iron triangles (John 2013).

Latour and Callon, have through their Actor Network Theory (ANT) emphasised a 'sociology of association' (Latour 2005) the main principle of which—moving beyond the social as a given—is to trace multiple associations and translations between actors—both human and non-human—operating within certain networks. Once actors/actants are enrolled, social interests are temporarily stabilised. These allegiances function to build specific forms of truth, through moments of translation and finally mobilisation. ANT allows description of the importance of allegiances and consensus building as a form of legitimisation, especially in policymaking, even if not entirely providing a theory determining causality. This opens up the question as to how such support is harnessed and perhaps how policy itself 'acts' with discursive power within such networks.

The centrality of ANT is about the heterogeneous network. In other words, the participation of multiple actors forms the structured pattern of network among humans and non-humans in which the scientific language becomes a medium of communication. In a sense, ANT

maintains people and objects as equal and also clarifies that this position does not treat humans as machines in theorisation. However, it highlights that social agent or actor is not a body alone, rather a patterned network of heterogeneous relations that are social in nature.

Like earlier proponents of sociology of knowledge, Law maintains that knowledge is a social product or outcome of a heterogeneous network generated through constant interaction between people and machines, animals, texts, money and architecture, etc. The task of sociologists of science is to characterise these networks in their heterogeneity, and explore how they come to be patterned to generate, organise and co-produce knowledge in which exploring the social relations in terms of power, resistance and domination becomes the prime means for addressing the social inequality in the process of manufacturing knowledge. We often see disorder not in a single block, but in the network itself. The existence of a permanent social order depends on local process of patterning, ordering and resistance. Understanding such processes helps us explore the social conditions which contribute to the persistence of power, domination and resistance. One may examine 'network as resource' like agents, devices, technologies, etc, that contributes to the survival of the network itself.

Policy networks incorporate a variety of government agencies, key legislators, pressure groups, relevant business and industry representatives, consultants and policy analysts and journalists, through which policies are forged (Scoones 2006). To extend a policy, research project, or development initiative to other spheres, networks require actors who are protagonists or 'policy entrepreneurs' (Hart and Victor 1993). These actors play "crucial roles in publicising an issue, succinctly defining the urgency of a problem and offering the possibility of a solution" (Latour 1996); entrepreneurs and their 'interpretative communities' allow for further enrolment (ibid.) and they "participate in the established order as if its presentations were reality" (Latour 2005). While policy thus tends to reflect political interests, these arguments further suggest that discourses and political interests influence each other, and both are shaped within and reshape existing networks and institutional structures or rules of the game (Law and Callon 1992). Policy decisions also do not automatically reflect evidence gathered to inform decision makers. Rather, 'science' may align with vested interests, is formed within and by various networks, or in cases can be

entirely neglected. Narratives, such as pro-poor development serve as a means to enroll and propagate support, a means to sell rather than direct specific ends. Thus, focus needs to be given towards understanding how policies are formed by the actions of actors within their various policy networks, dissecting underlying discourses and narratives in a given context.

Science and agriculture are inherently politically and culturally conditioned. Science and agriculture are shaped through the policies of the state and various socio-political actors, viz. state-regulated institutions. Public policy is crucial to understand the changes that have taken place in science and agriculture. Public policy is influenced by and influences several other fields of study and is highly interdisciplinary in nature. It is important to note that public policy is not just a government action, since non-action at times has deliberate consequences. As Jones (1984: 27) states: "Public policy is a goal directed or purposive course of action followed by an actor or a set of actors in an attempt to deal with a particular problem".

To understand how the National Mission on Biodiesel (NMB) was introduced as a mission at the policy level in India, here focus will be on the creation of the policy network at the central level and actors that supported the NMB and how in turn the actors formed various networks to support this initiative. After emphasising on the networks at the policy level, we examine how the NMB was established across the state level. As stated earlier, the NMB initially emerged and progressed rapidly across India as a result of national and regional networks comprising actors from the government (politicians, bureaucrats, policymakers), research centres, private companies, and Non-Governmental Organisations (NGOs) who actively supported its promotion. We argue that three types of networks namely government-led, research-led and private company and NGO-led networks were pivotal in the promotion and uptake of the NMB across the different states in India.

1.2.3 Social Construction of Technology (SCOT)

In the 1980s and 1990s, the old view of users as passive consumers of technology was replaced in some areas of technology studies, and one of the first approaches to draw attention to users was the SCOT approach. The question is who exactly are these users? Who defines them, who speaks for them, and how are they conceived by the designers of a

technology? Theorists of SCOT conceive of users as a social group that plays a part in the construction of technology (Pinch and Bijker 1987). The SCOT approach concentrates on the interpretative flexibility of a technology, and how different social groups construct radically different meanings of a technology. Such studies focus on the early stages of development when the users are viewed as the shaping agents. Once 'stabilisation' is reached interpretative flexibility vanishes and a predominant use emerges (Pinch and Bijker 1987; Bijker 1995). This approach of SCOT was highly criticised, because even after stabilisation is reached users could still actively modify stable technologies (Hughie Mackay and Gillespie 1992).

Other STS scholars have focused on how users are configured or represented by designers? This approach firstly introduces the notion of the user as a reader of a text and emphasizes on the interpretative flexibility of technological objects and processes that may delimit this flexibility (Woolgar 1991). The configuration is a two way process: the designers configure the users, but they are in turn configured by the users and their own organisations (Mackay et al. 2000). The capacity of the designers to configure the user can be constrained by the powerful groups within organisations which design projects and normally in large organisations the designers have to abide by specific methods and procedures that constrain design practices (Oudshoorn, Rommes, and Stienstra 2004). Other scholars have further argued that the configuration process is not restricted to the actors within the companies producing the technology, and have in turn focused on the configuration work carried out by journalists, public sector agencies, policymakers, and social movements acting as spokespersons for users (ibid.).

The second notion in the approach to user-technology relationship is the concept of 'script'. "The concept of script tries to capture how technological objects enable or constrain human relations, as well as relationships between people and things" (Oudshoorn and Pinch 2003). Akrich (1992) compares a technical object to a film script. Just like a film script, technical objects encompass a framework of action along with the actors and the space in which they act. She suggests that technologists anticipate the interests, skills, motives, and behaviour of future users and in turn their needs are represented in the design of the new product.

Subsequently, technologies contain a script: "they attribute and delegate specific competencies, actions, and responsibilities to users and technological artifacts" (Oudshoorn and Pinch 2003). However, this approach has a limitation — it stresses more on designers and technological objects and in turn under-emphasizes the cultural and social processes that shape how a technological script is read. The biography of a technology reveals that it is not just the actual, real-life users who matter, but ideas about the user-user representations are equally important in the relationships between users and technology (Lindsay 2003).

When the NMB was envisioned, the designers (policymakers, government officials, scientists) identified the rural users and their roles, however they did not perceive the extensive and heterogenous nature of different social groups of users (farmers and landless labourers) and how their resistance or shortcomings would in turn affect the outcome of the programme. The designers constructed a static image of the users and assigned roles to them and did not foresee the presence of other imagined users and how they could configure the technology. Lindsay (2003) depicts the role of users and argues that there is much more to the imagined users than the image constructed by certain groups of developers of the technology. She argues that user representations encompass many other users and they do not exist in isolation. It is argued that that the developers of the biodiesel mission in India envisioned the farmers and landless labourers as mere passive recipients of the technology and did not anticipate their cultural and social impacts on the progress of the NMB.

The cultural relations in a particular area play a vital role in the manner in which the rural actors adopt or accept a particular technology. Any study of technology/development initiative and the role of the users should situate the technological practices within the community where the technology is being introduced. This is important in addressing the role of the three types of regional networks researched in this thesis. In Madhya Pradesh, the focus is on the role of researchers in promoting the cultivation of jatropha; in Chhattisgarh, the emphasis is on the role of government officials in promoting the cultivation of jatropha, and in Rajasthan, the role of officials from private companies and NGOs in promoting the cultivation of jatropha is studied. Based on the cultural practices of the rural actors and their

perception of the actors promoting the NMB across the different networks the adoption and consequences of the NMB differed. Hence it is imperative to analyse cultural practices and social relations of a community/region prior to introducing a new technology/development initiative or policy.

1.3 Users of Technology

The study focuses on the adoption and consequences of the NMB from the perspective of the users (government officials, scientists, professionals from private companies and NGOs, farmers and landless labourers). As this thesis draws from Social Construction of Technology (SCOT), we argue that it is important to discuss the role of various actors (government officials, scientists, policymakers, professionals from private companies and NGOs, farmers and labourers) in promoting and adopting the NMB. A range of studies and research done on biofuels focus on the globally integrated biofuel network (GIBN), biofuel complex, biofuel assemblage, governance processes in India, land issues, related consequences of the NMB in India. However, we argue that there is a gap in the literature on biofuels pertaining to the role of users and the social construction of this technology in both India and elsewhere. To address this gap the present study focuses on the various actors such as government officials, scientists, policymakers, professionals from private companies and NGOs, farmers and labourers and their role in the promotion and adoption of NMB. We further emphasise on how the rural actors – landless labourers and farmers were affected by the NMB. Prior to the discussion on SCOT, we would like to explain what we mean by the term ‘user’. The term ‘user’ often implies to a person/group of people who use a particular technology. Hence in case of the NMB the user technically refers to the people who buy biodiesel and use it in their cars. In this thesis the user does not refer to the end user of the biodiesel technology rather it focuses on the users of the NMB as a rural development initiative namely the farmers and landless labourers who took up the cultivation of jatropha. Hence to clarify again the farmers and landless labourers are not classified as producers of the oilseed for the production of biodiesel but as users of the rural development initiative as they are the ones who cultivate jatropha under the NMB.

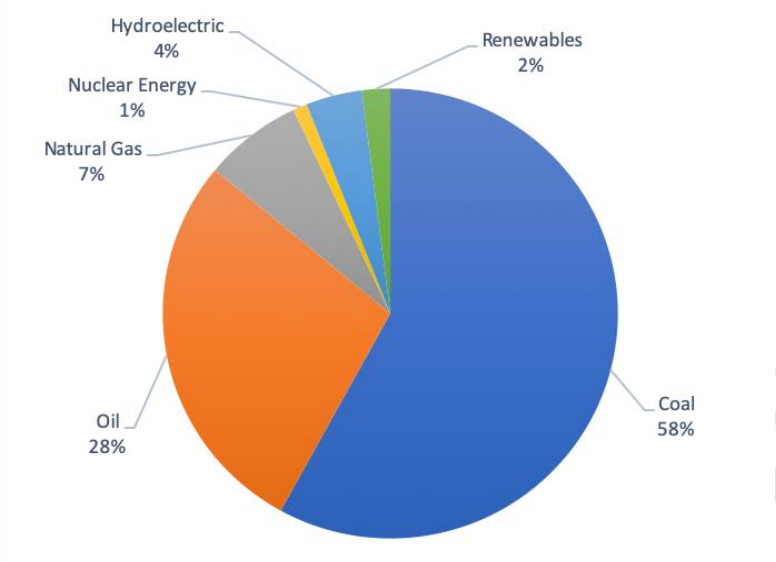
To reveal how the NMB is viewed differently by various actors promoting it and why the rural actors (farmers and landless labourers) adopt it and in turn how it affects them, we draw on the literature focusing on the role of users and their practices from STS. Users and technology are often viewed as separate objects of research, but in reality, users and technology are two sides of the same problem — as co-constructed (Oudshoorn and Pinch 2003). The general argument is that users are not passive recipients or consumers of the technology; they are also active agents of change who shape the trajectory of innovation (Kline and Pinch 1996; Oudshoorn and Pinch 2003). STS literature also mentions that the two spheres are co-constructed; users may shape the trajectory of innovation, but the technology also has an impact on their daily lives (Gieryn 2006).

Before moving on to our discussion on the narratives about biofuels as renewable, sustainable and clean energy and how these have played a pivotal role in enabling recent biofuel projects, we will take a brief look at the current energy scenario in India.

1.4 An Overview of Energy Scenario in India

Rapid industrialisation coupled with per capita energy consumption has tremendously increased the demand for different sources of energy such as, coal, electricity from nuclear and hydro, natural gas and oil. In India, per capita energy consumption shows the compound annual growth rate (CGAR) of 2.54 per cent for the period 2011-12 to 2017-18 (GoI 2019). Figure 1.1 depicts the energy basket of India.

Figure 1.1: India Energy Mix in 2015



Source: Government of India (2017)

Among the energy sources oil is the most convenient portable source of energy which contributes to twenty eight percent of India's total energy demand after coal which fulfils fifty eight per cent of the demand as shown in Figure 1.1. India consumes four percent of the total world oil production and is among the top three consumers of the oil after the US and China as on 2017 (EIA 2017[1]). However, India is not among the top producers of oil in the world. Table 1.1 shows the trends of foreign trade in crude oil in India.

Table 1.1 suggests that India is highly depended on import of crude oil. There has been an increase of 3.04 per cent in the net imports of crude oil in a year during the period 2016-17 to 2017-18. If we see the import in a long term, the net import has increased from 132.78 million tonnes to 220.43 million tonnes within a decade from 2008-09 to 2017-18.

[1] https://www.eia.gov/tools/faqs/faq.php?id=709&t=6

Table 1.1: Trends in Foreign Trade in Crude Oil and Petroleum Products in India

Year	Crude Oil (Million Tonne)			Petroleum Products (Million Tonne)		
	Production	Net Imports	Availability	Production	Net Imports	Availability
1	2	3	4=2+3	5	6	7=5+6
2008-09	33.51	132.78	166.28	155.15	-20.36	134.79
2009-10	33.69	159.26	192.95	184.61	-36.49	148.12
2010-11	37.68	163.60	201.28	194.82	-41.70	153.12
2011-12	38.09	171.73	209.82	203.20	-44.99	158.21
2012-13	37.86	184.80	222.66	217.74	-47.05	170.69
2013-14	37.79	189.24	227.03	220.76	-51.17	169.59
2014-15	37.46	189.43	226.90	221.14	-42.63	178.51
2015-16	36.94	202.85	239.79	231.92	-31.08	200.84
2016-17	36.01	213.93	249.94	243.55	-29.23	214.32
2017-18(P)*	35.68	220.43	256.12	254.40	-31.37	223.03
Growth rate of 2017-18 over 2016-17(%)	**-0.90**	**3.04**	**2.47**	**4.45**	**7.34**	**4.06**

*Provisional

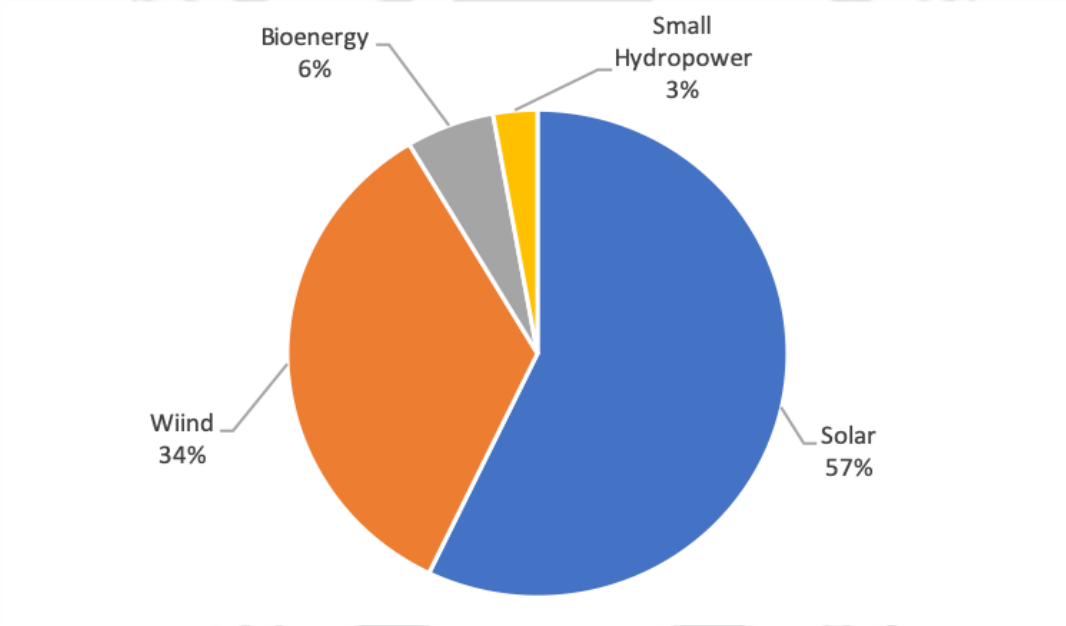
Source: Government of India (2019)

In the background of high oil import, finite oil reserves in the country, increasing demand for oil, and thereby stress on foreign exchequer, the Government of India emphasised on alternative sources of energy. According to the Government of India, it is pertinent to look for alternative sources which would be renewable and sustainable (GoI 2003). Among various options such as solar and wind, biofuel is considered as one of the prominent sources of energy which is to be harnessed from organic sources. Moreover, the Government of India aims to produce 175 giga watts (GW) of energy from renewable energy sources that includes

100 GW from solar energy, 60 GW from wind power, 10 GW from biomass and 5GW from small hydro power by the year 2022 (GoI 2017). This estimate in renewable energy segment would contribute six per cent of total energy production as compared to two per cent as mentioned in the Figure 1.1 (GoI 2017).

Figure 1.2 shows the combination of all sources of energy within the renewable segment. The contribution of bioenergy is six per cent after the energy from solar and wind. Energy from biomass comprises methanol, ethanol, and biodiesel that has to produce from agricultural harvests, waste, and used cooking oil.

Figure 1.2: Renewable Energy Mix Expected by 2022



Source: Government of India (2017)

In the following section we focus on bioenergy segment, particularly biofuels, namely: ethanol and biodiesel. The reason of emphasising on biofuels lies in the fact that blending of ethanol and biodiesel, respectively in petrol and diesel, has been mandated in the Government of India's biofuel policies and missions (e.g. GoI 2003, 2008, 2018). Table 1.2 and Table 1.3 respectively depict the scenario of ethanol and biodiesel production and blending limit.

Table 1.2: Production of Ethanol and Blending Achieved

Year	Quantity (crore litre)	Blending Percentage (%)
2012-13	15.4	0.67
2013-14	38.0	1.53
2014-15	67.4	2.33
2015-16	111.4	3.51
2016-17	66.5	2.07
2017-18	150.5	4.22

Source: Government of India (2018)

Table 1.3: Biodiesel Procured by OMCs for Blending

Year	Biodiesel Procured by OMCs^ for Blending (crore litre)
2015-16	1.19
2016-17	3.59
2017-18	4.36
2018-19	8.21

^Oil Marketing Companies

Source: Government of India (2018)

The Government of India has issued the National Policy on Biofuels (NPB) 2018 in continuation to the National Mission on Biodiesel 2003 and the National Policy on Biofuels 2009. In the current policy, the NPB 2018, the government targets to achieve ten per cent of ethanol blend and five per cent for biodiesel blended oil by the year 2030. These blending targets have been narrowed down, from twenty per cent, in the current policy because previous targets could not be achieved as depicted in the Table 1.2 and Table 1.3.

The report of the committee on development of biofuel selected jatropha as a suitable crop for the production of biodiesel in India (GoI 2003). As per the report jatropha plantation would cover 13.4 million hectares of land across the nation to achieve ten per cent of

biodiesel blending. However, these targets could not be reached at set time line, one of the reports on biofuels estimates 19.8 million hectares of land for jatropha cultivation if ten per cent blending target is to be achieved (Purohit and Dhar 2015). Against this backdrop, it becomes pertinent to understand the implications emerging from such large jatropha plantation in India.

In the following section we bring up the narratives about biofuels as renewable, sustainable and clean energy and how these have played a pivotal role in enabling recent jatropha projects in India even after or in the midst of skepticism of biofuels' trajectory.

1.5 'Construction' of a Biofuel Plant—Jatropha

There are over 400 species of trees bearing non-edible oilseeds in India (GoI 2009). The potential of all these species claimed to be considered, depending on their techno-economic viability for production of biofuels. It has been possible to identify jatropha as the "most suitable tree borne oilseed for production of bio-diesel in view of its ability to thrive under a variety of agro-climatic conditions, low gestation period and higher seed yield" (GoI 2009: 7). Jatropha, a member of the euphorbia family, is originated in Central America. Heller (1996) argues that jatropha with other accessions from Cape Verde was transported to different regions of Asia and Africa by Portuguese navigators. Other studies have also been conducted to find the similarities in molecular profile between Indian accessions and those from Cape Verde (Heller 1996; Dias, Missio, and Dias 2012). It has long been used around the world as a source of lamp oil and soap, and as a hedging plant (Kovarik 1998).

The fruits of jatropha contain considerable quantity of oil but poisonous in nature for consumption by animals and humans. Industrial requirement for soap production and burning at domestic level have been the applications of jatropha oil since a long time in India. Scientists were aware of such property of jatropha but oil extraction as a fuel for engines was not in their agenda at the time of plantation for landscape development. Later on, jatropha oil blended with diesel and commensurability of it tested with minor modifications in engine; other parameters, viz. compression-ratio, temperature, exhaust-matters, power were compared with diesel. Results were courageous, various institute published the results of testing, some vehicle demonstrated the applicability of jatropha oil as eco-friendly.

The biodiesel initiative was promoted by the Government of India as a 'pro-poor' initiative that would use 'wastelands' for the cultivation of jatropha (GoI 2003). The rural farmers and labourers questioned the classification of land as 'wasteland' and 'unused' and were against the cultivation of jatropha on the common property resources (Baka 2014). Jatropha is being publicised as a hardy crop that is resistant to pests and requires minimum inputs, but the farmers observe that it is susceptible to pest attacks, and its yield rates get reduced markedly without inputs of irrigation and fertilisers (Ariza-Montobbio, et al. 2010). The actors involved in oil production said the quality and quantity of oil produce from jatropha varied significantly across different genotypes of the seed. Another major concern is the model of contract farming adopted by domestic and international companies which having drastic consequences on the rural farmers, in turn being contradictory to the development goals of the project.

While the global assemblage of biofuels created an enabling environment for the adoption of biofuel production the world over, concerns were being raised by the UN, FAO, OXFAM, local NGOs, and researchers about the environment friendly production process of biofuels, and that arable land was being diverted for biofuels production which was in turn raising food prices (Oxfam 2008). The development of biofuels was involved in debates on monoculture, food versus oil, land grabbing, and the not so green production of biofuels (ibid.). While there were concerns over the viability and sustainability of biofuels globally, voices of skepticism were also arising in India on the production and viability of biofuels (Ariza-Montobbio and Lele 2010; Baka and Bailis 2014). Various actors from research organisations and NGOs, farmers, and labourers raised issues of concern which were in opposition to the goals and claims of the development initiative.

1.6 The Scientific Claim-making

The process of resistance and accommodation performed by actants and actors sets the locus of any scientific experiments (Pickering 1992). Drawing parallels from Pickering's arguments the opinions on the merits and potentials of biofuels become strongly polarised. Public debates around the world contain both optimistic praise for and pessimistic warnings

against biofuels as a substitute for fossil fuels. Participants in these debates make reference to and claim support from scientific knowledge. However, it is difficult for both the general public and decision-makers to discern what should count as well-founded knowledge or not in these different claims and scenarios. It is therefore pertinent for (STS) to explore what role science—"the conventional arbiter in disputes about factual matters" (Hansen 2014: 74)—plays in the controversies around biofuel policies. While the developments of biofuels have begun to register in the STS literature and neighbouring fields, most of the existing critical social science research on biofuels focuses on the economic interests driving the development of the evolving 'biofuels complex' (Mol 2007; Borras 2010) and the discursive formation of an emerging 'bio-based knowledge economy' (Birch, Levidow, and Papaioannou 2010). So far, less attention has been devoted to the specific role played by scientific knowledge production and claims-making in this development. What role does science play in the controversies around biofuels?

Hansen (2014) complements the existing literature with more detailed attention to the scientific dimension of the controversies about biofuels. It follows the scientific uncertainty and incomplete knowledge bases, in particular in domains such as nuclear power, climate change and biotechnology. Some observers suggest that scientific uncertainties are often the cause of political controversies over novel technologies (Winner 1980; Beck 1992). Winner (1980) attaches inherent political attributes to technologies. In other cases it has been suggested that political competition is likely to fuel scientific controversy (Jasanoff 2004). Combining these perspectives, an influential contribution suggests that the boundaries between science and politics are eroding (Nowotny, Scott and Gibbons 2001).

The contestation between various scientific claims can be categorized into three conflicting perspectives about biofuels. First is a reductionist bio-processing perspective emanating from biosciences and bioengineering disciplines, here changes at molecular level directed towards achieving divergent application of biofuel sources. The second is holistic bioscarcity perspective emanating from ecology and life-cycle analysis (Hansen 2014). This perspective focuses on adverse consequences of biofuel on ecological cycle. And, the third perspective has apprehensions over adoption of biofuels in either situation. This perspective is in favour

of biofuels as a product of biomass at rural level but not for mass production at industrial level.

Bio-processing Perspective

The scientific arguments used to support biofuels are delivered predominantly by researchers with a disciplinary base in biochemistry and molecular biology. A guiding vision is the bio-processing as a generic process technology, whereby any biomass can be transformed into a plant-based equivalent of crude oil. For convenience, we shall refer to these scientists as 'bio-processor'. Their participation in the debate entails a two-pronged argument in favour of biofuels. First, they suggest that plants are the most powerful capturer of energy from the sun through photosynthesis. Significant scientific progress has been made recently in extracting this energy through various biochemical process technologies, in particular enzymatic degradation of celluloses. These process technologies will allegedly allow a second-generation extraction of energy from crop residues and non-food crops, which were impossible to process with a positive energy balance in the past (Pandey, Bhargava and Mandal 2010).

Thus, while recognising some of the problems raised by biofuel sceptics, the bio-processors suggest that novel process technologies will allow for significant synergies in production chains and they envision a symbiotic mode of production where residues from one process serve as input in the next process, described with phrases such as '"up-cycle" rather than "re-cycle" (Edrisi, et al. 2015). When presented in public, the science is framed as an optimistic narrative suggesting scientific ingenuity as key to solving most of the pressing challenges facing the world (Hansen 2014).

In this assessment, the major obstacles to such a technological trajectory gaining momentum in India are rooted in political and regulatory hesitations, rather than technical limitations per se (Kumar, et al. 2012). In this view, the hesitation is primarily caused by pressure from environmental NGOs, which fail to differentiate between good and bad ways of producing biofuels, referring to the distinction between first- and second-generation fuels. Resistance to change is thus primarily ascribed to deficient rationality and vested interests among

NGOs. Not all environmental NGOs reject biofuels, though. Similar scientific claims regarding the potential benefits of biochemical research can be found in a report from the World Wildlife Foundation (WWF 2013), which undertook a joint project with the biotech company Novozymes to explore paths towards a 'low-carbon economy'. They suggest that industrial biotechnology can enable a shift toward a biobased economy, based on production paradigms relying on biological processes and, as with natural ecosystems, use natural inputs, expend minimum amounts of energy and do not produce waste as all materials discarded by one process are inputs for another process and are reused in the ecosystem (ibid.). While not particularly keen to promote biofuels for cars, WWF aligns themselves with the optimistic scenarios entailed in the image of a low-carbon economy promoted by bio-processors, accepting that bridging technologies are a necessary step on the way (cf. Richardson 2012).

It is characteristic that the scientific claims of bio-processors rely on a reductionistic 'building-blocks' metaphor, where scientific advances at the molecular level allow for novel combinations based on organic matter to be scaled up in bio-process. Such bio-processes are projected to solve more macro-level societal problems via step-by-step expansion. When observed upwards from the molecular level, biomass is framed as an abundant and extremely flexible resource, and any potential scarcity is associated with suboptimal uses and regulatory rigidities. We can thus observe how authorised scientific knowledge generated at the molecular level is coupled with societal visions in two ways. On the one hand science-based projections are made about what can be done in future technological applications. These projections are not established scientific facts, but derive credibility from their scientist sources. On the other hand, the projections locate the responsibility for the realisation—or not—of future applications outside the scientific system and direct demands at policymakers. There is a noteworthy temporal dimension to this coupling: current research results are used to envision future technological applications, the realisation of which requires particular policy choices in the present. This also illustrates the asymmetries between scientists and other policy actors, where scientific authority is translated into political credibility, which cannot easily be dismissed by non-scientist policy actors. For this,

counter-expertise in the form of alternative scientific perspectives and interpretations is required.

"Holistic Bioscarcity" Perspective

The scientific arguments articulated against biofuels in debates derive primarily from researchers with a disciplinary base in environmental science, ecology and life-cycle analysis. These scholars argue that although seemingly abundant at present, biomass will be a limited resource in the future. Depleting fossil resources have sparked emerging technologies in many sectors reliant on biomass (fuel, heat and power, chemical engineering, etc. in addition to food production). Because these technologies develop in parallel, the central problem from a life-cycle analysis perspective is how to prioritise between different uses of biomass and avoid the detrimental knock-on effects of land-use change in the developing world when demands grow in the rich countries. In such analyses liquid biofuels, whether first or second generation, do not perform well. Findlater and Kandikar (2011) argue that even the theoretically maximum available biomass is going to run out long before we have fulfilled more pressing needs than road transport. The energy sector in the rich parts of the world is potentially a much larger 'customer' for biomass than the global food market. This means that fulfilling even a fraction of the needs of the transport sector worldwide will demand a relatively large share of the areas needed for food production (Findlater and Kandlikar 2011).

Liquid biofuels are a primary object of technological innovation today, but from a life-cycle analysis perspective, road transport represents a suboptimal use of biomass. Furthermore, life-cycle analysts suggest that intensified biomass production is expected to produce a number of undesirable knock-on effects in terms of technological lock-ins, delaying the transition from combustion engines to electric or hydrogen-powered vehicles or even more substantial changes in infrastructure to lower the demands for individualised mobility. Also, biomass shortages in the richer parts of the world are likely to call for imports from economically and ecologically more vulnerable parts of the world. The current India target is to use 30 per cent biofuels in road transport in 2030 (IEA 2011) that requires around 125 per cent of their arable area. In the meantime, consumption is projected to go up, meaning

that the fossil consumption stays at the same level in absolute terms. What should then be the next step? How will they solve other problems such as dependency on fossil fuels, CO_2 emissions etc., through imports of biomass?

There is some contention about how to delimit the systemic aspects of biofuels production and consumption. Nevertheless, the general consensus suggests that liquid biofuels constitute a suboptimal use of biomass. When bio-processors compare (future second generation) biofuels favourably to currently used fossil fuels, they ignore the fact that the same biomass could be used more cost effectively to reduce CO_2 emissions if applied differently (Dias, Missio, and Dias 2012). Publicly, this perspective is framed in more pessimistic tones, suggesting that incumbent interests are the primary obstacles for more sustainable development (Pecina-Quintero et al. 2014). The scientific perspective of life-cycle analysis thus moves holistically from a macro scale to consider biomass as a scarce and fragile resource, depending critically on many interlocking factors in the production chain. This perspective compares estimates of the energy available to extract from biomass, either at the regional or global level and the estimated energy required to refine it for different purposes. Researchers may disagree about the most suitable metrics for different problems (e.g. energy balances, CO_2 removal, land-use change, etc.). These arguments suggest that there is a fundamental agreement among academic life-cycle analysts that liquid biofuel for the transport sector is suboptimal while taking alternative uses into consideration. However, the earlier agenda for this area was captured by commercial interests to serve as a 'green agenda' for the petrol industry, car manufactures and agriculture (Sarewitz 2004).

Similar to the bio-processing perspective, it can be observed a coupling between authorised scientific knowledge—here regarding circulation of energy and resources—and projections about future developments linked to extra-scientific concerns. Also here, scientists speak authoritatively about what ought to be done. Temporally, this perspective places less significance on the distinction between first- and second-generation biomass. It suggests that future growth in biomass consumption will perhaps shift production patterns in ways that will cancel any sustainability gains and shift the burden onto fragile ecologies and

communities. In the following section we examine in more detail how these scientific claims are coupled with policy debates.

Jatropha is a drought-resistant, perennial plant living up to 50 years and has the capability to grow on marginal soils. It requires little irrigation and grows in all types of soils, thus making jatropha a more sustainable choice than other vegetable oils. Jatropha biodiesel can be used for decentralized micro-grid electricity generation at village or taluka (suburb) level and as a replacement for diesel fuel in irrigation pump sets, diesel generators and also as an alternative to kerosene (Zhou and Thomson 2009). Although there is reason to be enthusiastic about jatropha's potential as a biodiesel feedstock in India and beyond, there is one rather sobering concern: despite the fact that jatropha grows abundantly in the wild, it has never really been domesticated. Its yield is not predictable, the conditions that best suit its growth are not well defined and the potential environmental impacts of large-scale cultivation are not understood at all (Fairless 2007).

Some scientists have had apprehensions about large-scale jatropha plantation. They are suspicious about a premature push to cultivate jatropha, inadequate understanding of the basic agronomics could lead to unproductive agriculture. The internal differentiation of scientific communication suggests that the political struggles about biofuels are better understood as propelled by scientific diversity rather than scientific uncertainty. By scientific diversity (Hansen 2014) it can be referred to situations where different but in principle equally scientific perspectives relevant to a given policy problem are propagated simultaneously, leading to different policy recommendations. Such plurality of perspectives is possible because of the disciplinary differentiation of scientific knowledge production. Rather, the challenges to policymakers and the general public are rooted in the fact that different branches of scientific knowledge bear upon complex policy problems in different ways, creating what (Sarewitz 2004) has called an 'excess of objectivity', i.e. multiple, possibly conflicting, scientific claims are at the disposal of decision-makers simultaneously with no meta-criterion to adjudicate.

1.7 Biofuels Policy and Development Narratives

Godin (2009) postulates that common narratives or commanding interpretations are supported for various reasons and serve a diversity of contradictory interests. Keeley and Scoones (2003) point out that there is a history of selling a story: a narrative of potential crises which in turn result in the adoption of particular set of practices and actions, which require international attention. Biofuels evoked interest the world over due to the creation and promotion of global narratives exemplifying the benefits of biofuels while positioning the interests of various actors (White, et al. 2012). Similarly, national narratives were created and promoted in India to popularise the NMB and foster their acceptance across the various stakeholders. Some of the promotional claims on biofuels are as follows:

> …Kyoto Protocol cannot be achieved without providing a large role for biofuels by 2050…[Biofuels] are appropriate for […] their simplicity; […] production via well-known agricultural technologies;…potential for mitigation of climate warming; …the use of existing engines;…their potential to facilitate worldwide mobilization;…their potential as a directly available energy source with good public acceptance; a common set of regulations;…their potential to create benefits for rural areas, including employment creation.
>
> (Singh, et al. 2014)

For a long period of time policy analysis considers stories as inferior forms of information and reasoning, and favoured rigorous scientific methods and objective data (Van Eeten 2006). Policy analyst Majone (1989: 251), demonstrates that "good policy analysis revolves around crafting an argument, rather than applying logic and science. This development paved the way for different and new approaches in policy analysis as alternatives to the dominant empiricist models. Among the new options, narrative policy analysis emerges as one of them (Roe and Van Eeten 2004).

Policy narratives are stories bearing a beginning, middle, and ending which describe or define events in a certain manner inherently shaping the outcome of policy decisions. Narratives function to simplify complex development problems because they represent particular ways of thinking and arguing which involve the political activity of naming and classifying and exclude other ways of thinking, thereby decreasing the scope for

policymakers to ponder about new alternatives or approaches (ibid.). Feldman, et al. (2004: 147) emphasise the importance of stories in policy-making and state:

> Stories carry information relevant to decision making and enable participants in policy and administration to predict, empower and even fashion change. Stories have been said to mediate reality and construct political space and are critical constitutive forces in politics and public policy making.
>
> (Feldman, et al. 2004: 147)

Policy frameworks are often constructed as narratives or stories that give meaning to a situation. Conceptual frameworks in science, technology and innovation policies are usually constructed in the form of a story or narrative (Godin 2009). A narrative serves to simplify complex issues and creates a story which feeds in to the interests of various actors who will form alliances to promote the policy. For example, Van, Eijck et al. (2014), and Keeley and Scoones (2003) dwell upon the narratives of African deforestation and savannization which were reinforced and supported by various actors.

Biofuels subscribe to science, technology and innovation, and development policy options. While promoting developmental issues biofuel narratives have put science and technology on the political agenda. Godin (2009) advocates that a narrative on science, technology and innovation commences with the suggestion that something new is happening in the economy, and the new phenomenon or change will generate good returns. He states that, a "narrative is either in the form of hype, hyperbole or utopia, suggesting that enormous outcomes are looming" Godin (2009: 17). Narratives are backed by statistics because they suggest it is necessary to know about the new phenomenon or change, and statistics are needed to validate that a change is happening.

The biofuels narratives suggest that biofuels are green sources of energy and would reduce greenhouse gas (GHG) emissions, and in turn would reduce the consumption of fossil fuels. While supporting the promotion and introduction of a new technology, biofuels served developmental issues such as rural employment and improvement of livelihoods (Mol 2010). Even though narratives tend to simplify complex development, and science and technology

issues, they have been widely criticised, as they lead to 'blueprint' development, prescribing particular set of solutions and reducing the space for alternatives (Thompson 2008). Narratives are created and promoted by policymakers and policy-networks and they often tend to serve the interests of these epistemic communities, and in the process reduce the role of indigenous groups by justifying the role of experts and outsiders in the policy process (Roe and Van Eeten 2004). According to Roe and Van Eeten, these experts and outsiders argue that local people do not have the necessary knowledge to handle their local resources, hence there is a crisis and the local people need the help of development experts and professionally trained resource managers. Development narratives marginalise the interests of indigenous groups by "labelling and categorising them" and tend to conceive the target groups as "passive objects of policy rather than as active subjects", this has been referred to as the 'disarming of labelling' (Roe 1991, 292). Roe argues that narratives tend to oversimplify complex development issues and are often based on shaky scientific facts. While the narratives oversimplifying issues tend to misrepresent a situation thus result in decisions being formed based on false information.

1.8 Critique from Agrarian Political Economy

Various authors have adopted a range of approaches to explain the recent expansion of biofuels. For example, one of the approaches which are being applied to understand global change is the role of 'networks' and 'flows' as "architects of global modernity" (Castells 1996 cited in Mol 2007). Castells (2004) states that "networks constitute the fundamental pattern of life, of all kinds of life" and argues that networks are pervasive and they formed the backbone of societies. Mol (2007) adopts this terminology to explain the rise of a Global Integrated Biofuel Network (GIBN). He discusses the emergence of a GIBN characterised by the concentration of actors, objects, relations which formed biofuels regions at the national, local, and international level. According to him local biofuels regions expanded into national biofuels regions and the increase in national biofuels regions in a number of countries advanced the spread of biofuels globally.

Smith (2010: 13) employs the terminology of 'global assemblages' to explain the expansion of biofuels world over–"Global assemblages represent the tangible configurations through which global forms of techno-science, economic rationalism, and expert systems gain significance and shape". The global assemblage on biofuels resulted in the proliferation of biofuel targets the world over and by 2015, at the start of the present study, twenty seven countries had policy under consideration or had enacted mandatory requirements for biofuels to be blended with traditional transport fuels, and forty had legislation to promote biofuels (Wilkinson 2018). USA, UK, European Union, Brazil, China, Canada, India, and South Africa had introduced blending targets and many more countries were joining the list.

Borras, et al. (2010: 575) speak about a new agrarian political economy created by the 'biofuel complex' and offer perspectives from political economy, political sociology, and political ecology to comprehend the "new agrarian relations". They focus on the emergent political and social relations in the biofuel complex, politics of representation, institutional structures, discursive frames through which biofuels are promoted/opposed, impacts of biofuel investments, and forms of resistance or support that unite or divide actors in the biofuel complex. Mol (2007) and Smith (2010) in their work discuss the broad nature of an emergent GIBN, global assemblage, while Borras et al. (2010) use their framework of a biofuel complex to explain the complex sociopolitical relationship amongst actors in Brazil, India, Africa, the USA, and Europe.

A range of authors have focused on the emergence of biofuels (particularly biodiesel) in India, for example, Findlater and Kandlikar (2011) focuses on the National Mission on Biodiesel by analysing the policy processes and her work centres on rural governance in Andhra Pradesh, Ariza, et al. (2010) discuss the role of soil fertility and low yields of jatropha in Tamil Nadu; Rajagopal (2008) speaks about the environmental, economic, and policy aspects of biofuels; Baka (2014) reveals the politics of wasteland and land grabbing associated with biofuels in Tamil Nadu; Tompsett (2010) centres on the biofuel policy as a development project in Rajasthan; and Shinoj et al. (2011) did an economic assessment of a biodiesel value chain in India (Ariza-Montobbio and Lele 2010; Rajagopal 2008; Tompsett 2010). A majority of these papers either focus on the role of the government, research centres

or private companies in promoting biodiesel production in a particular state in India. We argue that the NMB in India emerged and progressed as a result of national and regional networks comprising actors from the government (politicians, bureaucrats, policymakers), research centres, private companies, and NGOs who actively supported the promotion of the NMB.

Biofuels—liquid fuels produced from biomass—have been promoted and developed by the biotech industry and policy actors as an allegedly sustainable alternative to fossil fuels (Carolan 2009b; White and Dasgupta 2010). However, during the past decade other actors have voiced concerns about potentially detrimental social and environmental effects from large-scale biofuel production (Shinoj et al. 2011; White and Dasgupta 2010). In 2007 the 'fuel versus food debate' highlighted a link between the increased use of bioethanol in the USA and rising food prices in the world market (Paarlberg 2010). However, it is claimed that the Indian approach to biofuels is somewhat different to the current international approaches which could lead to conflict with food security. "It is based solely on non-food feed-stocks to be raised on degraded or wastelands that are not suited to agriculture," thus avoiding a possible conflict of fuel vs. food security (GoI 2009: 9).

Several claims have been made time and again in popular as well as academic writings that project biofuels with the potential to revive peasant agriculture and stimulate rural development. These writings claim that the production of biofuels as feed-stock imply a comparative advantage for developing countries. For example, the argument is that biofuels are both labor and land intensive, which commensurate with developing countries that are in general land and labour abundant (Pimentel et al. 2009). Similarly, Clancy's argument is not very different: "biofuels are tropical crops; their yield in per hectare of land is much higher than those of temperate crops" (Clancy 2008). These claims should be examined against the backdrop of issues pertaining to persistent agrarian crises in those regions.

Biofuels feedstocks such as sugarcane, maize and jatropha are typically land-intensive and low-value crops. Profits attached with such crops are usually post-harvest treatments and latter production processes; it is also derived from the provision of input viz. seeds, irrigation

setups and fertilizers. This is the reason for those studies that concern agrarian development and see the potential of biofuels for an optimistic change, give the cautionary remarks over alleged benefits. White and Dasgupta question (2010) the share of profit likely to benefit the local communities from biofuels expansion. They further argue that large scale plantations—where smallholder contract-farming is practiced—are the zones of poverty, not of prosperity for dinary people. Further, it is worth mentioning that most of the tropical hotspots lie in political territory of the developing countries and inhabited by the people who are considered as indigenous, and economically and politically deprived (Kellert, et al. 2000) . Biofuels as genetically modified crop are promising the new markets for biotech products. Smallholders will fall completely under the control of giant corporations which monopolise the new technologies (Dauvergne and Neville 2010).

The projected biofuels expansion is planned to be based in the large areas of land which are not yet covered by the laws governing private property relations but have the status of 'public' or 'state' lands. These lands provide livelihoods to millions of cultivators and forest dwellers under a wide variety of tenure relationships depending upon collective or individuals, and customary or semi-official.

Bernstein summarises the research objectives of an agrarian political economy approach in terms of questions such as, "who owns what? Who does what? Who gets what? What they do with it?" (Bernstein 2010). Following these queries White and Dasgupta (2010) further add a question, "what do they do to each other?" to capture the relational and political dimensions of property, labor process and structure of accumulation. Scholars of agrarian political economy has applied the same analytical tools of critical studies to biofuels plantation and expansion which have been applied to historial episodes of rapid expansion of large-scale, industrialized, capitalist, monocrop agriculture system in plantation and contract farming forms.

As argued by Dauvergne and Neville (2010), at the global level, while biofuels are integrating agricultural and energy industries and opening new roles for some countries in the global economy, the global political dynamics that they reveal are less novel. The

dynamics that we see with agrofuels appear likely to mimic the patterns that others have observed in the palm oil industry, with the emerging economies of the South integrating their economies with Northern countries and multinational companies, in complex relationships that blur the lines between donors and recipients of aid, and producers and consumers of goods (Dauvergne and Neville 2009). The dynamics that we see there in agrofuels expansion in the way that corporate capital inter acts with local government, local elites and local cultivators and workers may not be something new, but simply a repetition of well-known dynamics in the expansion of the world's major agrarian commodities, whether in the colonial period or more recently.

1.9 Research Gaps

Various studies on the biofuels in India have focused either on rural governance, policy-processes, economic feasibility of biodiesel production, or yield rates of jatropha. The study is an attempt to address this gap by depicting the presence of social practices, behaviour, and status of various actors who enrolled into the biofuels network. Another gap that the study wants to address is the trajectory of jatropha as a biofuel crop in the backdrop of scientific claim-making and policy-framing. The reviewed literatures assume certain established characteristics of jatropha which establishes it as a fuel. The present study does not aim to make conclusions but to situate pluralist debates on biofuels in India. This study intends to locate the presence of different socio-technological systems that constructed a bush into a crop for the 'improvement' and subsequently a crop for the 'development'.

1.10 Rationale for the Study

The rationale for selecting the study is twofold:

a. What make cultivation of biofuels distinct from other branch of agriculture are the speed of expansion and the enormous scale of plantation, which may be more rapid than previous agro-commodity booms in colonial or post-colonial history, with correspondingly greater implications. It is imperative to understand the emergence and trajectory of such crops from the science and technology studies perspective.
b. Other aspects possibly distinguishing biofuels from most forms of production are their convenient green packaging, the crops for growth and development, which

perhaps makes corporate land acquisition, forest conversion and introduction of contested biotechnologies more publicly acceptable. These factors give reasons to understand the discourses and narratives on biofuels promotions.

1.11 Research Questions

The present study, from science, technology and society perspective, centers on the following questions:

a. How does jatropha emerge as a biofuel crop in the backdrop of post-colonial developments in India?
b. What are the narratives supporting the development of biofuels in India and how are these narratives forming the discourse in scientific claim-making and policy-framing?
c. Why does the rural farming community cultivate jatropha and how does the network of biofuels affect them?

1.12 Objectives of the Study

The objectives of the present study are to:

a. Understand the emergence of jatropha as 'wonder crop' and its ability to grow on 'wastelands' and to locate its trajectory of resistance and accommodation in the process of enrollment in biofuels network.
b. Understand how biofuels have been popularised in India. It is imperative to analyse the pluralist narratives promoting biofuels and their underlying assumption in discourses of scientific claim-making and policy-framing.
c. Explore the impediments and risks involved in cultivation of biofuels from the perspective of the farming community and to examine the implications emanating from the cultivation.

1.13 Methodology and the Sites of Data Collection

The present study from the STS perspective, particularly from Actor-Network Theory (ANT) and Social Construction of Technology (SCOT), examines the responses of the farming community engaged in jatropha cultivation, scientists and policy framers, government

officials from selected scientific institutes and biofuels development boards. For addressing the first and second research questions, the study banks on the archival material including the back volumes of the journals, books, articles, web sources, and so on. Further, in-depth interviews are conducted to record the responses of the scientists and policymakers from selected scientific institutions located in centre and state-funded universities and research institutions, mission-oriented institutions and their organisations in biofuels research and policy-making. Tamil Nadu, Karnataka, Chhattisgarh, Madhya Pradesh, Gujrat, Maharashtra, Rajasthan and Uttar Pradesh are the prominent places of jatropha cultivation in India. Initially data were obtained from documents – government reports, policy papers, reports, academic journals, websites, and newspapers. Then we attended seminars and workshops on biofuels and interacted with key speakers and informants. Purposive sampling and snowball sampling methods are employed to select the institutions and participants. Mulkay and Gilbert (1992) highlight why it is important to interview scientists in science and technology studies.

> Not only do different scientist's accounts differ; not only do each scientist's accounts vary between letters, lab notebooks, interviews, conference proceedings, research papers, and so on; but each scientist furnishes radically different versions of events within, say, a single recorded interview transcript or a single session of a taped conference discussion.
>
> (Mulkay and Gilbert 1992)

In qualitative research, sampling is viewed as a very complex issue (Coyne 1997). Johnson and Waterfield (2004) state that the sampling strategy in qualitative research does not look to accomplish statistical representativeness; rather, it strives for diversity within the study population. According to them, "the sample must be sufficient to generate depth rather than breadth and may comprise a small number of participants or just one" (Johnson and Waterfield 2004). Sample size depends upon the research questions and aims of the study and the type of data to be collected. Murphy and Dingwall (2003) argued that, "using non-probability sampling methods in qualitative research is best seen as a pragmatic compromise between breadth and depth". Therefore, it can be argued that in qualitative research there should be a balance between depth and breadth of sample size.

The majority of the data are generated in semi-natural settings by interacting / interviewing with the scientists and the government officials at their laboratory or office. The data is collected through semi-structured in-depth interviews with sixty six scientists and government officials from Indian Council of Agricultural Research (ICAR) and Council of Scientific and Industrial Research (CSIR)-sponsored research institutes, central and state universities, and state biofuel development boards. The rationale for selection of the field sites lies in the fact that the institutes have been engaged in research and development of renewable energy technologies, especially production of biofuels. Indeed, a few of them are 'Centre of Excellence in Biofuels' and nodal centers entrusted with the cultivation of jatropha, development of the right genotype of the plant, and the responsibility of promoting widespread plantations of jatropha in the states and producing biodiesel subsequently.

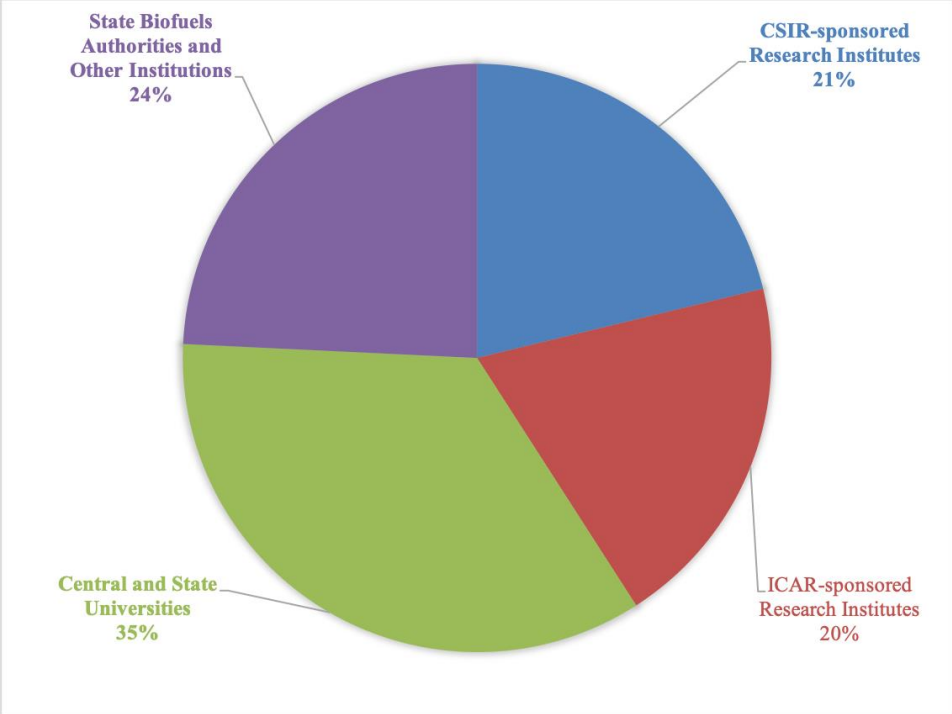
The present study employes purposive sampling method. The potential respondents are selected from two different categories, namely: the scientific community and the farming community. Purposive sampling is carried out at two different levels. One is at the institute level and the other is at the scientist level. At the institute level, only those CSIR and ICAR-sponsored institutes, central and state universities, state biofuel development authorities and other institutes which are extensively involved in biofuel research, were selected for the study. An internet-based screening by visiting web page of each institutes was conducted. Finally, 07 CSIR, 12 ICAR-sponsored institutes, 17 central and state universities and 10 other research institutes and sate biofuel authorities were found to be extensively involved in biofuel research. However, 04 (out of 7) CSIR, 08 (out of 12) ICAR, 13 (out of 17) central and state universities, and 08 (out of 10) biofuel authorities and the other institutes accepted the invitation to participate in the study (Table 1.4). An internet-based screening of scientists and officials was conducted after visiting their online profiles at their institute's web page. Finally, 115 respondents were screened for the study. These selected scientists and officials were invited through email and telephone to participate in the study. Out of 115 selected scientists and official, 66 agreed to participate in the study.

Table 1.4: Institute-wise Distribution of Respondents (the Scientific Community)

Name of the Institute	Number of Respondents
CSIR-sponsored Research Institute	**14**
CSIR-Central Salt and Marine Chemicals Research Institute, Bhavnagar	6
CSIR-Indian Institute of Chemical Technology, Hyderabad	2
CSIR-Indian Institute of Petroleum, Dehradun	2
CSIR-National Botanical Research Institute, Lucknow	4
ICAR-sponsored Research Institutes	**13**
ICAR-Central Institute of Agricultural Engineering, Bhopal	1
ICAR-Central Research Institute for Dryland Agriculture, Hyderabad	2
ICAR-National Bureau of Plant Genetics, Hyderabad	1
ICAR-Directorate of Oilseed Research, Hyderabad	2
ICAR-Indian Agricultural Statistics Research Institute, New Delhi	1
ICAR-Central Agroforestry Research Institute, New Delhi	2
ICAR-Natural Resource Management Division, New Delhi	2
ICAR-Indian Grassland and Fodder Research Institute, Jhansi	2
Central and State Universities	**23**
G.B. Pant University of Agriculture and Technology, Pantnagar	1
Maharana Pratap University of Agriculture and Technology, Udaipur	2
University of Agricultural Sciences, Bengaluru	2
Indian Institute of Science, Bengaluru	2
Tamil Nadu Agricultural University, Coimbatore	2
University of Delhi, New Delhi	1
Indian Institute of Technology Delhi, New Delhi	2
University of Hyderabad, Hyderabad	2
Indian Institute of Technology Guwahati, Guwahati	2

Indira Gandhi Agricultural University, Raipur	2
Institute of Environment and Sustainable Development, BHU	2
Jawaharlal Nehru Agricultural University, Jabalpur	1
University of Petroleum and Energy Studies, Dehradun	2
State Biofuels Authorities and Other Institutions	**16**
Karnataka State Biofuel Development Board, Bengaluru	2
Chhattisgarh Biofuel Development Authority, Raipur	3
Rajasthan Biofuel Authority, Jaipur	1
Centre for Social Forestry and Eco-Rehabilitation, Allahabad	2
Council of Forestry Research and Education, Dehradun	2
Hassan Biofuel Park and Agricultural College, Hassan	2
North-Eastern Regional Centre, TERI, Guwahati	2
DRDO-Defence Institute of Bio-Energy Research, Haldwani	2
Total	**66**

Figure 1.3: Percentage Distribution of the Respondents



The third research question is being examined through the responses of the users of technology, this includes the farming community engaged in cultivation of biofuels crop in India. For this, a multi-sited ethnography was undertaken to understand the social order, practices, and daily life of the farmers and landless labourers who are / were undertaking jatropha cultivation. In the field of STS various ethnographic studies (Latour 1993, Cooper et al. 1995, Latour 1996, Downey and Dumit 1998) have employed intensive fieldwork methods to show how power relations and cultural meanings are embedded in the adoption of a technology. Initially, we conducted one-to-one interviews to get the perspective of the respondents on jatropha cultivation, their problems, yield rates and other related details. The next step was to attain a better understanding of why communities had adopted jatropha cultivation and for that we had to get a better insight of the opinions of the people in a group, how they interacted with each other, and if there were any power relations between them. Hence we adopted group interviews popularly referred to as focus groups discussion. We were able to conduct four focus group discussion during the field study. Krueger and Casey (2000: 18) have defined the focus group as "a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment". In a focus group data are generated by interaction between participants, while the participants present their views they also get a chance to listen to other people. They listen and reflect on what is being said and additional material is triggered as a response to it. As the discussion progresses back and forth, individual responses become clearer and refined, and graduate to a deeper and more considered level (ibid.).

During the first phase of the NMB, biodiesel production was actively taken up by many state governments and it was beyond the scope of this research to carry out fieldwork and collect data from all the states involved. A multi-site approach was adopted, once a better understanding was acquired of the states actively adopting jatropha cultivation and biodiesel production. We realised that it would be possible to conduct fieldwork in two or three states. Initially we selected six states – Andhra Pradesh, Chhattisgarh, Karnataka, Madhya Pradesh, Rajasthan and Uttar Pradesh, and did a reconnaissance study. Based on access to sites, permission to collect data, government's jatropha programmes/schemes, and presence of

research centres, private companies, and NGOs – Chhattisgarh, Madhya Pradesh and Rajasthan were chosen as the sites to conduct the fieldwork. Each site was unique in the type of actors and networks used to promote the NMB and the NPB.

Chhattisgarh

Chhattisgarh was the first state to express an active interest in the biodiesel mission and was the forerunner in the advancement and uptake of biodiesel production in India. On 26 January 2005, the Government of Chhattisgarh established the Chhattisgarh Biofuel Development Authority (CBDA), which was designated as the primary organisation entrusted with the responsibility of promoting widespread plantations of jatropha in the state and producing biodiesel subsequently. In Chhattisgarh, the state government played a key role in promoting the cultivation of jatropha and hence we traced the creation of the government-led biodiesel network in this state. In this state fieldwork was carried out in two districts—Durg and Bilaspur. Two regions were identified—Godhi, a village in Durg district, and Pendra, a block in Bilaspur district—based on differences in accessibility to agricultural technologies, agricultural practices and demographic factors.

Madhya Pradesh

Madhya Pradesh is one of the leading states in implementing renewable energy development programmes such as solar, wind, and bioenergy. *Madhya Pradesh Urja Vikas Nigam* (Madhya Pradesh Energy Development Council) is the nodal agency entrusted with the cultivation of jatropha in coordination with the State Agriculture Department, the Forest Department and the Rural Development Department. Madhya Pradesh Urja Vikas Nigam in coordination with the other departments involves in the development of nurseries for jatropha plantation, and linking employment generation proggrmmes with jatropha plantation. In this state fieldwork was carried out in Jabalpur. The Jawaharlal Nehru Agricultural University (JNAU) is located in Jabalpur and the 'Centre of Excellence in Biofuels' was established as a multidisciplinary research facility in June 2006 at JNAU. This centre was funded to research on jatropha and develop the right genotype for cultivation. In Jabalpur, the researchers from the Centre of Excellence in Biofuels played a key role in promoting the cultivation of jatropha in the state. The presence of a state biodiesel policy,

nodal agency, and centre of excellence in biofuels were the main reasons on selecting Madhya Pradesh as one of the states to conduct fieldwork to map the role of a *research-led* network in promoting the biofuel policies and mission.

Rajasthan

In September 2005, the state government of Rajasthan announced a policy for jatropha plantation through the horticulture program of state's Employment Guarantee Scheme (EGS). The state government of Rajasthan aimed to develop jatropha-specific cultivation practices and promote the cultivation of jatropha across different districts. In this state fieldwork was carried out in Rajsamand and Udaipur. In Udaipur and the surrounding region, many private companies and NGOs are involved in the cultivation of jatropha, hence we studied the private company and NGO-led biofuel network in this area. In this region, the fieldwork was carried out in three villages: Devla, Manavto Ka Guda and Gogunda. The main language spoken in Rajasthan is Rajasthani, however a majority of the people speak Hindi and hence we conducted the interviews in Hindi. In Udaipur, numerous NGOs are promoting jatropha cultivation across the state and they have ties with the private companies and Maharana Pratap University of Agriculture and Technology, Udaipur.

Content analysis is used to analyse the interview transcripts. Content analysis is a general term for a number of different strategies used to analyse text (Powers and Knapp 2006). It is a systematic coding and categorising approaches used for exploring large amount of textual information unobtrusively to determine trends and patterns of words used, their frequencies, their relationships and the structures and discourses of communication (Marying 2000). The analysis of interview data started first with the transcription, i.e. the written translation of a recorded interview. All interviews were transcribed. Although it was a laborious and time-consuming task, this exercise helped in bringing closer to the data in terms of identifying key themes and in-depth analysis of various narratives of research participants (Bryman 2004). Initially, the interviews were conducted and transcriptions were done simultaneously as there was some time between interviews. The initial transcriptions were very helpful in refining interview schedule and questionnaires further. For emergent themes, transcripts were analysed by content and then coding was carried out. Coding was done on the basis of

themes and off-repeated statements. Emerging themes were named and the data obtained from different stakeholders were collated and included in each of the themes. The analysis of interview data are presented in Chapters II, III and IV.

Ethical issues in qualitative research are one of the most important aspects which cannot be ignored as they directly related to the integrity of the research work (Bryman 2004). There is an imperative to ensure the anonymity, privacy, confidentiality and informed consent with respect to the participants in the research process (Daymon and Holloway 2002). Empirical data were collected using face-to-face interviews and recorded using a digital voice recorder with the permission of the interviewee. Research participants were asked for written consent for the participating into the interview and recording to take place. In addition, participants were assured that their responses would be kept confidential and also their identifications were anonymised. Indeed, to maintain the anonymity of the participant we use pseudonyms though the thesis. Their reference in the data chapter was highlighted as per the institutional affiliation.

1.14 Structure of the study

The thesis is arranged in terms of five chapters. The first chapter introduces various facets of the thesis such as review of literature comprising discourses in biofuels with theoretical framework of STS, research gasps in the literature, rationale for the study, research questions, objectives of the study, methods of analysis and structure of the study.

The second chapter corresponds to the first research question and objective of the present study. This chapter provides the global and Indian experiences of biofuels. We discuss the rise of biofuels and biofuel policies world over and how many developed and developing countries have either formed or are introducing biofuel policies, mandates, and missions. We try to locate the emergence of jatropha in the backdrop of post-colonial development policies in India. We attempt to trace the genealogy of construction of wasteland in both colonial and post-colonial India. In turn, we discuss the Indian biofuel policies and missions in the pretext of wasteland development. The chapter brings up the crisis narratives and wasteland

development programmes in the pretext of 'idea of improvement'. The chapter also attempt to sketch biofuel network drawing theoretical frame from the Actor-network theory.

The third chapter under a broad canvas, corresponding to second research question and objective of the study, captures the responses of various actors involved in the promotion of biofuels, viz. scientific community engaged in research in biofuels from selected scientific institutions located in central and state-funded universities and research institutions, officials from selected state biofuels development boards, and other government and non-government organisations engaged in biofuel cultivation, production and promotion in India. In this chapter we aim to capture the materiality and agency of jatropha, discursive nature of scientific claim-making in biofuel promotion or opposition, and in turn we move on to find the presence of sociotechnical system for biofuels in India. This chapter depicts the interaction between jatropha and the scientific community in the background of diverse ways in which research and development on jatropha is carried out in social, political and technological facets. An attempt is also made to understand the dialectic of resistance and accommodation mediated between jatropha and the scientist in the process of development of a biofuel feedstock. This chapter argues that the development of variety and hybrid is employed in terms of accommodation from the scientific community to address the resistance presented by jatropha in while mediating with the elements of biophysical, domestication and disease resistance.

The fourth explores the impediments and risks involved in the cultivation of biofuels, particularly jatropha, from the perspective of the farming community. This chapter under the broader schema of third research question and objective of the present study engages with the farming community who cultivate jatropha in India. We attempt to juxtapose responses of the farming community and the scientific community against this backdrop: when jatropha reaches from the laboratories to the farmlands. This chapter reflects upon the national and local narratives supporting the development of biofuels and how these narratives played an important part in the emergence of local biofuel narratives across different states and in turn encouraged the hasty creation of biofuel policies, mandates, and missions. Here we attempt to respond on the question how the national biodiesel narratives while being influenced by

the global narratives displayed regional characteristics specific to India's goals to produce biodiesel. Thereby, this chapter depicts the varying cultural associations, practices, and tacit meanings among the users in the field sites. It further discusses the rural users as users of technology across the three states form different types of linkages with the actors in biofuel networks.

The fifth and final chapter summarises the findings of the study. Based on the findings, the chapter makes concluding remarks in relation to the argument presented in earlier chapters. The concluding section further sheds light on the limitations of the present study and points out the need for further research in the field.

Chapter II

'Construction' of a Biofuel Plant: Trajectory of Jatropha from 'Wasteland' to Farmland

Introduction

The projection of World Energy Outlook (IEA 2013) estimates the rise of 56 per cent in global marketed energy consumption from 2010 to 2040. Owing to an escalated demand of energy, social and political unrest unfolded in several Middle Eastern and African economies and insufficient oil supply response raised the price of oil in 2010 (IEA 2011). Another incident which preceded the surge in oil prices is in the 1970s and 1980s when several nations were in the midst of the cold war. This led to oil embargo, national security and environmental problems that created the situation for the search for alternative fuels (Kovarik 1998).

From the projected levels of energy demand and available resources it is increasingly apparent that new sources of science and technology should be tapped to meet the ever increasing demand for energy. Among the varying options being explored, biofuels have emerged as a viable option. The Government of India followed the global trend for energy demand and launched the National Mission on Biodiesel in 2003 to produce biofuels domestically. Jatropha was identified as a potential crop for biofuel feedstock to be cultivated in 'wasteland'. In this chapter we attempt to address the first research question of the present study. We try to locate the emergence of jatropha against the backdrop of post-colonial development policies in India. We also attempt to trace the genealogy of construction of wasteland in both colonial and post-colonial India. In turn, we discuss the Indian biofuel policies and missions in the pretext of wasteland development. Further, we move on to sketch the biofuel network drawing theoretical frame from the actor-network theory.

2.1 Introducing Biofuels—Global Experiences

The term 'biofuel' refers to energy produced from biomass through processes such as solid combustion, gasification or fermentation (Demirbas 2009). Biofuels are liquid fuels produced from 'renewable resources', mainly derived from organic matter and are a versatile

source of energy. Biofuels have gained popularity as a global solution due to their potential to "reshape livelihoods, patterns of resource consumption, environments and agro-food production systems" (Smith 2010).

Biofuels present one of many enterprising but complicated technologies characterising what may be broadly considered the 'bioeconomy' – moving from the strictures of the genetic revolution to wider perspectives of replacing the fossil-based economy with a bio-based one. From a broad economic perspective, the bioeconomy refers to a set of economic activities relating to the invention, development, production and use of biological products and processes which can contribute to socio-economic impacts in developed and developing countries (OECD 2009; Mallick 2011).

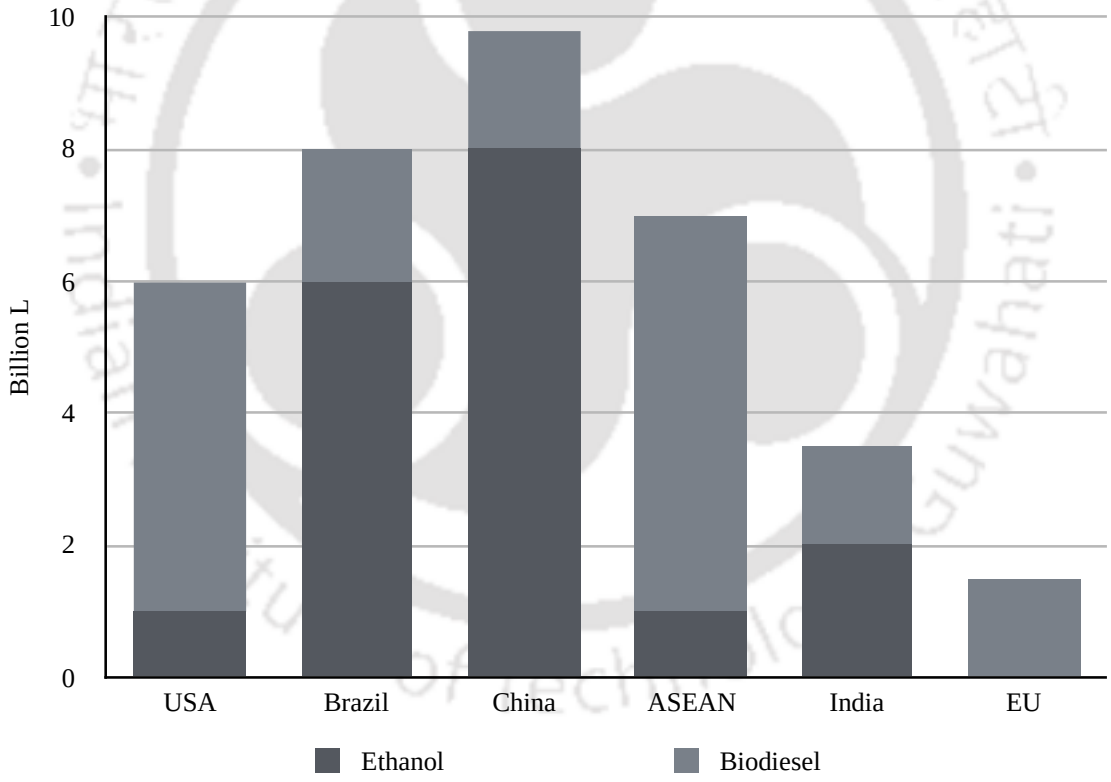
Mol (2007) states that "biofuels are booming" because they are portrayed as a panacea for problems of energy insecurity, climate change, and rural under-development. These 'win-win' narratives have premised the development of a 'globally integrated biofuel network (GIBN)' (Mol 2007), 'biofuels complex' (Borras and Franco 2012), or 'assemblage' (Smith 2010), which has been driven largely by policies in the 'North', the European Union, and the United States in particular (Hollander 2010).

Policies such as the EU's Directive 2003/30 EC have generated market signals and provided subsidies leading to a proliferation of biofuel projects, targets, and missions, mustering significant research into their dynamics and impacts, associated technologies, and best practices amongst others. Following Brazil's success on biofuels production, the supportive framework is also increasingly supported by the 'South' (Dauvergne and Neville 2009). Figure 2.1 shows the expected growth of biofuels, both biodiesel and ethanol, production in major economies of the world.

On the one hand, the USA administration sets corn ethanol targets to 35 billion gallons by 2020 with huge subsidies to the agribusiness giants ADM, Bunge, Cargill and other multinational companies. On the other, the European Union matched this with a 10 per cent target for biofuels mix in transport fuels by 2020. Following this example, the UK's

Gallagher Report (Gallagher 2008) estimated, via a mid-range scenario of land use, that by 2020 about 500 million more hectares of land, one third more than currently (at 2008, as per Gallagher Report) under cultivation, would be required to meet the global demand for biofuels. Estimates suggest that the Northern fuel needs could be met now with the conversion of 70 per cent of European farmland to fuel crops, and the entire US corn and soy harvest (Holt-Gimenez 2007). However, given biofuel subsidies, targets and enabling Kyoto protocols, corporations and financiers are investing massively in biofuel production in the global South. These combined processes are creating an emergent global biofuel complex.

Figure 2.1: Expected growth in biofuels market 2019-2024



Source: World Energy Outlook (2019)

2.2 Introducing Biofuels—Indian Experiences

The previous section introduced biofuels and how a GIBN, global assemblage, or a biofuel complex, are being used to explain the rise of biofuels and biofuel policies the world over.

India was among the countries who were advocating biofuels programmes, missions, and policies. The Government of India introduced the Ethanol Blending Programme, and the National Mission on Biodiesel (NMB) as policy options which supported the production and blending of bioethanol and biodiesel in petrol and high speed diesel respectively. Prior to the global recession the Indian economy was growing at 8 per cent per annum and India was among the top five consumers of energy in the world along with the USA, China, Germany and Russian Federation (World Bank 2008). Despite the recession having an impact on the growth rate, the demand for energy has still been rising and to meet the accelerating requirements the GoI has been promoting renewable sources of energy production. The NMB aligned with the aims of the government to promote green sources of energy production.

The NMB was publicised by the Government of India as a development initiative and the objective of introducing a new technology was portrayed as an environmentally friendly method of producing energy domestically, in the process of generating rural employment, improving the agriculture sector, and reducing oil imports (GoI 2003). It aimed at producing biodiesel from jatropha, a non-edible oil seed, which would be cultivated on land under the scheme of joint forestry management (JFM), hedges around agricultural land, 'culturable fallow lands', stretches of public land along railway tracks, highways, and canals, and dry, marginal 'wastelands' (ibid.). In the section 2.4 we will discuss the NMB in detail.

Global as well as Indian experiences of biofuels depict the situations when the need for an alternative renewable energy source seems necessary. Combining these global and local contexts for biofuels, the emergence of jatropha as a fuel can be conceptualized within the definition of fuel where "fuel is a … peculiar technology nothing is inherently fuel. Fuel is simply a term for carrier of energy" (Carolan 2009a: 422). The presence of sociotechnical system at the time identified jatropha as a carrier of energy and then it came into the ambit of fuel. Jatropha—or biofuels per say—as a new carrier of energy is compared and contested with fossil fuels irrespective of efficiency or other comparable parameters. There is nothing inevitable and natural in emergence of jatropha as biofuel: it has been in application in rural areas for burning from long time. But, what was distinct during the drafting of the NMB?

The drafting of the NMB was influenced by the global and local attributes imparted by sociotechnical system placed in combination of state, research organizations, development and funding organizations, automobile sectors, and oil sectors. It does not imply that no resistance was observed, rather initial oppositions were also emanating from the same sociotechnical system. Carolan (2009a) locates the technological trajectory of biofuels in the late nineteenth and early twentieth century by examining the farm chemurgic movement, changing agriculture policies, mechanization trends within agriculture and the invention of leaded gasoline. He argues that the technological trajectory of biofuels innovation is an outcome of a sociotechnical system influenced by social force.

2.3 Imaginaries of Energy in India: Historical Underpinnings

STS scholars have long argued for recognition of social, political, cultural and moral dimensions of technologies that enable specific choices embodied in technological capacities. For instance, Jasanoff and Kim (2009) come up with the term "sociotechnical imaginaries" to understand imagined futures of a nation that is associated with technological capacities. Sociotechnical imaginaries draw attention to a vision of better future which can be achieved by combining national policy and technoscience. The state legitimises investment, project, and deployment of science and technology for a better collective future. State actors envision biofuels as a technological instrument which can address the pressing demand for energy. In this vein sociotechnical imaginaries for biofuels is imagined for future energy which is 'green', and can address a nation's salient challenges such as pollution, environmental degradation, national energy security and dependence on fossil fuel.

Technological projects for energy, and especially for renewable energy technologies in recent years (after the United Nations Framework Convention on Climate Change 1992), are presented to imagine a future which is feasible, attainable, and desirable for social necessities and order. To illustrate this point and to figure out the linkages between energy policies in pre and post independent India, we would like to discuss the Meghnad Saha's conceptulisation of energy, equity and justice in India.

Meghnad Saha – one of the legendary scientists of India and later decided to turn economist – took energy consumption as a measure of wealth of a nation. In 1936, he calculated the per capita energy consumption of different countries and found out high energy societies such the UK, the USA and Russian Federation. As per one of his estimates the average energy consumption of India was "90 units per year which was equal to that of Europe in the middle ages" (Seshadri and Visvanathan 2002). Saha found Lenin's Energetika programme for electrification of Russia as an inspiration and wished to establish the same for India. Thereon, he connected the vision of Lenin and Nehru. For Lenin the idea of development was based on the contract between State-Science-Economic, and his celebrated dictum was "Soviets+Electrification=Communism" (Visvanathan 2007: 192). Similarly, Nehru's emphasis on creation of mega dams was an index of science. What is notable here is the role of energy in linking science and development. His statement on dams as temples of modern India and temples of energy set the precedence for energy policies in postcolonial India.

In *The Communist Manifesto* Marx and Engels historically capture the role of an energy system in a particular society. If the windmill gave us feudalism the steam engine gave us industrial society (Marx and Engels 1967[1848]). Importance of the steam engine can be captured in their statement. Steam is the centre of law of thermodynamics. As per the law of thermodynamics, a mechanical work can be done from high gradient temperature to low gradient temperature body, and this work is irreversible unless there is no external supply of energy. This irreversibility does not align with classical Newtonian mechanics, which deals with the law of directionality, reversibility and conservation of energy. The motion of pendulum is a popular example to understand Newtonian mechanics. The reason of ambivalence between thermodynamics and classical mechanics is the concept of entropy. Entropy is used to differentiate between free energy available for work and unavailable energy in a system. For example, ash generated after burning the coal for heat represents the waste. This waste, the measure of unavailable energy is entropy. Why it becomes important to understand the concept of entropy, the reason lies, it is the marker of modern industrial society. Visvanathan shows through the lenses of C.V. Seshadri that the mechanics of steam engine carries along with it its anthropology of modernity (Seshadri and Visvanathan 2002).

Entropy emphasizes unavailable work, degradation and waste. Work and waste are the two friction wheels of our modern production system.

Seshadri was the first to point out disparity arising from the laws of thermodynamics in social arena. The law of thermodynamics states that work done in higher gradient temperature is most precious works and work done in ambient temperature is a degraded form of energy. This understanding when applies to low energy societies such as third world countries it subverts the rights of the people whose livelihood is dependent on forest produce. Forests are one of the sources of multiplicity of use including food, fuelwood, wood, etc. for the tribals and peasants, and provide fuel for boiling sugar and smelting iron to local small industries. When forests are seen as just a source of pulp and paper industries, a potential spot to generate high gradient energy, then forests are converted into monoculture plantation. Plantation of poplar, eucalyptus and biofuel crops such as oil palm and jatropha are a few examples that has converted multispecies forests into a monoculture plantation. Seshadri and Balaji (1993) argue that when the energy polices of the state are based on modern science, it works against the interest of the tribals and peasants and deprives them from their rights of forest biomass access.

2.4 Idea of 'Improvement' and Appropriation of 'Wasteland' in Colonial and Post-colonial India

The scholarship in historical research on forestry and imperialism in south Asia brings up the intersections of everyday practices, consolidation of power and science in empire. Science as practice was a powerful instrument for empire which sought to change landscape and life of people associated with them. Control over nature through science was one of the aspects amongst subjugation of people by colonial rule. David Arnold (2005) in *The Tropics and The Travelling Gaze*, sketches the genealogy of the idea of improvement and resource management in colonial India. He argues that the science in empire was deployed to observe and appropriate an unfamiliar landscape. The land which was "an object of colonial fear and desire, utility and aesthetics" (Arnold 2005: 1). Evaluation, reinterpretation and representation of Indian landscape were in the core of science as practice in colonial era. In this process, many parts of India witnessed irreversible changes in forest, pasture and

agrarian relations, for example, emergence of forest demarcation and bureaucratisation in the name of scientific conservation, tea and coffee plantation and massive movement of labour.

Arnold relates the way India turned into site of research field station and laboratory where many facets of botany, animal husbandry, soil science, forest, agriculture, hydrology, to name a few, were experimented in the colonial period and replicated in other colonies all over the world, by which these institutions drew line between imported science as expert knowledge and indigenous knowledge. He clarifies that, "it would be a mistake ... to presume indigenous ideas and agency had an equal role or that some kind of open, mutually respectful discourse existed between Indian science and its European counterpart" (Arnold 2005:8). This process of regionalisation of knowledge bolstered the legitimation of scientific expertise in conservation policies and broke the hitherto existing symbiotic association of people and land in the colonial period.

Where Arnold claims that scientific endeavour during colonial period was more centred on aesthetics, improvement and conservation of land and forest, less on economic interest for empire, Rajan (2006) identifies economy as the primary interest on motivating state-science relationship during colonial period. According to him, land assessment, agrarian transformation and forest conservation generated increased revenue, agricultural commodities and huge wood and timber stock for British economy. Exotic plants and animals were also introduced to manage land and forest resources and to secure British economic advantage. This introduction was the result of various experiments on plants and animals held in India and other colonies. Colonial rule portrayed importation of exotic species as diffusion of science and development of colonies. Richard Drayton (2000) in *Nature's Government* explains how idea of development and improvement became instrumental in consolidation of empire through taming nature. The Empire introduced enterprises such as railway, telegraph, irrigation, plant and animal science as development projects for improving the material condition of colonies. Drayton clarifies, the main purpose was to improve material condition of empire's northern nations struggling with cold temperate weather by discipling nature and people situated in tropics. So scientific

enterprises, especially the science of plants, had much to do with the Empire's profits rather than interests of colonies.

By the early twentieth century, most of the institutions related with revenue assessment, land classification and forest conservation had taken a form of technocratic bureaucracy in colonial India. And, in 1927 Indian Forest Act came into operation with consolidation of law, revenue and science. Grove (1995) indicates that Indian forestry management was presented as a model of land management and conservation to proximate colonies and other parts of the world. It can be noted that the Indian Forest Act, 1927 captured the interest in aftermath of World War I, when the annual revenue of forest department tripled and quantity of timer sold by contractors 600,000 cubic feet in 1896-1897 to 8.3 million cubic feet in 1915-1916 (Sivaramakrishnan 2008). It would be interesting to mention that, as Barton (2002) shows, theories of climate change caused by deforestation were appearing from 1820s to 1920s in English and German journals and magazines. In Barton's words (2002: 33):

> It is in this milieu of broad-based discussion in scientific journals, magazines, and popular books that the climate theory was disseminated throughout the nineteenth century. No one narrow path was responsible, neither the island deforestation … nor the group of medical surgeons working for the East India company.

In one way where, Indian forest management was showcased as model for conservation, on the other global climate concerns started including deforestation as one of the emerging factors in wake of industrial revolution and its consequences.

The continuity between colonial and post-colonial land and forest management policies can be traced in the plan of the then Inspector General of Forest, 1941 and the national forest policy of 1952 – the first policy document of independent India pertaining to forest reserve and conservation. This policy acknowledges the contribution of India's forest towards the both World Wars. The forest policy of 1952 affirms the contribution of earlier forest policies and states that fundamental basis and concepts still hold good for independent India (GoI 1952). The policy also prioritises 'national interest' vis-à-vis a village on the ground of proximity of a village to a forest. Such unquestioning undertaking by the government of

independent India has impression of colonial norms, when the Inspector General of Forest's plan in 1941 states:

> The year 1855 was a memorable year in the history of Indian forestry. For, in that year, Lord Dalhousie, the then Governor General of India, enumerated for the first time an out-line of a permanent programme of forest administration. His proclamation laid down the ruling principle of *management of 'state forest'*, namely, that timber standing on a state forest was state property to which individuals had *no rights or claims.*
>
> (cf. Guha 1983: 1888, emphasis added)

Though there was a departure in forest management practices in the 1960s, the changed forestry practice emphasised on growing timber of economic interest such for pulp and paper industry. It is worthy to note that the forest management in post-colonial India is keeping the essence of colonial regime while shifting in forest policy. As earlier we have discussed colonial forest management policies exploited landscape and forest in the name of improvement and conservation. The introduction of exotic species which could grow faster to fulfil industrial demand in the 1960s and launch of social forestry to replace native species with fast growing plants in the 1970s are the instances of continued idea of development which is intact with improvement. For example, the social forestry programme came with a new plant prosopis to cater the demand of village fuelwood.

However, a few studies do come up with the optimistic outcome of social forestry programme, such as, Ghosh (2014) proclaims, in addition to environmental protection and livelihood of the rural people social forestry is helpful in the situation of flood and draught. According to him Jagadari, Saharanpur and Jamunanagar are the suitable example of social forestry programs which bolstered wood and timber industry through plantation of poplar and eucalyptus in the Indo-Gangatic plains. Given the importance to these plants, transportation of these timber was restricted outside the state growing the plantation.

2.5 'Wasteland' Development Programmes in Post-colonial India

In an effort to respond to energy demand, mitigate climate change and rural poverty, the Government of India started the NMB in 2003 to cultivate jatropha in 17.4 million hectares

of wasteland (GoI 2003). In the policy document of NMB erstwhile[2] classified marginal lands were considered wasteland. The classification of land into marginal or wasteland is not the first instance that surfaced with jatropha cultivation in 2003. Rather, the politics of wasteland classification has had a history of development initiatives in both colonial and post-colonial regimes. Here, we examine wasteland development programmes and attempt to draw parallels to current biofuel missions and policies.

Gidwani (1992) examines the wasteland development policies in colonial India, and depicts how the term wasteland as a phrase is ambiguously classified but widely recognised as 'bad'. The agenda of the colonial regime's policies was to eliminate the 'bad' and turn it into 'value'. What can be inferred that wasteland was a bad 'property' which requires 'improvement' so that it can be classified as a valued land. The triad of 'waste', 'value' and 'property' has an origin of demarcation of land in John Locke's classification of land. According to Locke (2011[1680]), lands which are not privately held are wastelands. Locke (2011[1680]:37) gauged wastelands in the terms of:

> The provisions serving to the support of human life, produced by one acre of inclosed and cultivated land, are ... ten times more than those which are yielded by an acre of land of an equal richness lying waste in common.

By positing this he meant the overall social welfare by the improvement of land lying out there in nature. For Locke private property is a natural right which is bestowed by God. Not improving one's property would be an immoral act. By pointing out this Locke's attribution of moral dimension to land (wasteland), Gidwani (1992) links the approach of the state towards land management policies in the colonial rule. Similarly, Whitehead (2010) explains, the term wasteland was used to differentiate land users in colonial India. This division was made in between tribal communities and private property holders, the earlier denoted as 'savage'—typical users of forest, and the later recognised as 'civilised'— private land owners. The attempt was to improve 'waste' for 'value' and turn 'savage' into 'civilised' (Guha 2014).

[2] Categorisation of land as per the Wasteland Map of India.

Such unethical and indiscriminate division of land into waste and value was not the part of colonial rule only, this persists in the post-colonial policies in the context of various wasteland development programmes. The state, often as an authority and agent of resource assessment, is being upholding its desire to bring disciplinary order in land classification. Perhaps the negative connotation attached to 'wasteland' by Locke is still continuing in present day policies. If this is the foundation of the post-colonial policies, then the premise: what is 'bad', it has to be 'improved' for larger social welfare, should be examined. And, is there any possibility to identify similar discourse pertaining to biofuel promotion?

Saigal (2011) outlines the shifting nature of wasteland development programmes. These programmes and policies are largely linked to India's contemporary policy objectives and have a dimension which relates to international inclination or constraint. These policies are often targeted to rural development. Here the objective is not to assess success or failure of a particular wasteland development policy, rather focus is on to identify differing perceptions of various stakeholders about 'wasteland'. According to Saigal (2011), wasteland development programs have five major shifts since post-colonial regime, namely:

a. food security (1950s-1970s)
b. social forestry (1970s-1980s)
c. rural development (1980s-1990s)
d. watershed development (1990s-2000s)
e. climate change (2000s onward)

It is to be noted that India's current biofuel policies and missions are part of country's larger policy to respond to climate change. Indeed, striking similarities can be drawn from the above mentioned development programmes which are not embracing the biofuel policies only, it sets a frame and pattern when these policies were commissioned. A few of the similarities and thereon trajectories are: emergence of a crisis narrative with impetus of international development factors, response of government to such perceived crisis, appointment of high-level committee to address the crisis, ambiguous assessment and monitoring of wasteland, and promoting these measures as an inevitable step for rural

development. There is an assumption of abandoned land which is unproductive and hence not in use. By wasteland development programmes unused land can be assessed and improved for larger welfare of the country. As we have discussed in section 2.4, in what national and international scenario the NMB and the NPB were introduced, and how biofuel cultivation specially jatropha got impetus to grow in wastelands.

We can mention other instances of perceived crisis and the state's response to address it. Land assessment and categorisation were the important elements in these policies. For example, the Green Revolution was introduced as panacea in the 1960s to counter famine and enable food security (Patel 2012). Factors for threshold of the Green Revolution were not limited to local critical condition in India, it was triggered by international development programmes and narratives. In the 1970s, another perceived energy crisis in developing world, which was confined to availability of fuelwood for domestic energy need, was addressed by implementing social forestry program across the country (Devi 2015). Between 1980s to 2000s, various policies and programmes were launched under the umbrella of rural development, viz. community based resource management, integrated rural development programme, watershed development programme etc. Last in the list is climate change mitigation programme(s) initiated in the 2000s by the Government of India to align itself with international concerns of global warming, climate change and energy security.

2.6 Mapping of Land for Biofuel Plantation

Since pre-colonial time wasteland has been a category under land revenue system (Guha and Gadgil 1992) in India. Governments of independent India continued with the category, however there have been some modifications in the context of wasteland categorisation with changing need of the time. For example, the establishment of National Commission on Agriculture (NCA) appeared in the pretext of global influence towards ecological modernisation in the 1970s. The NCA recommended optimisation of the country's forest and agricultural resources which could address the demand of both household and industry (GoI 1976). One of the recommendations was to transform forest into production forest, so that high value timer could cater industry, another was to convert contiguous blocks into energy blocks, where local community could fetch fuelwood (ibid). The social forestry

programme emerged against the backdrop of these recommendations to address the perceived conflict between timber wood and fuelwood. Underlying motive of social forestry was to reduce pressure on production forests by limiting community use of forest products.

With the launch of social forestry, the Government of India has been steadily expanding areas under wasteland development program to address degradation of land. Where earlier approaches focussed on isolated land patches, the shift came with social forestry was incorporation of contiguous block for development. The increase in scale of wasteland development impelled the government for private sector partnership. This collaboration attracted private sector, so that they could capitalise profit interest by 'improvement' of land.

Private sector and community participated with the Government of India under social forestry programme. Another two key developments within this line were commissioning of the National Bank for Agriculture and Development (NABARD) in 1981 to provide financial support to rural industries, and the National Wasteland Development Board (NWDB) in 1985 to define, assess, and classify land resources not coming under 'productive use'. This included lands alongside railway tracks, road and canal, boundary of agricultural field, and village wasteland. As per one of the estimates of NWDB (1987), 1.3 million hectare of forest cover has decreased annually between 1970s and 1980s. To compensate this recess, plantation of fodder and firewood targeted to cover 5 million hectare of wasteland per year (ibid).

The NWDB was also entrusted with defining and classifying wasteland in India. Identification of causes and consequences of land degradation has been the major motive of wasteland development policies. The NWDB aimed to design a consistent approach to identify land degradation causes and to prepare uniform database which can be used across the ministries and other state agencies. The NWDB (1987) identified ecological and economic processes causing land degradation and defined wasteland as:

> Wastelands refer to degraded lands which can be brought under vegetative cover with reasonable effort and which are currently lying under-utilized, and land

> which is deteriorating for lack of appropriate water and soil management or on account of natural causes.

Another state agency formed to prepare wasteland atlas of India, National Remote Sensing Agency (NRSA) asserts on resources degradation and population growth for wasteland formation. The agency started compling database of wasteland since 1986. The preamble of one of its report on wasteland supposes:

> Due to increasing population pressure, there is an excessive demand of land for both agricultural and non-agricultural uses. This has resulted in creation of vast stretches of wastelands such as degraded land, soil salinity, waterlogging, desertification, soil erosion etc., and the decrease in per capita cultivable land besides ecological imbalances.
>
> (GoI 2005)

Policymakers approach wasteland improvement to differentiate a land which is productive and which is not. In order to make distinction between productive and unproductive land they often come up with new categories. For example, lands owing to low productivity had gone out of production, lands never able to produce, or, lands show some potential for 'improvement'. Within these ambiguous differentiation, new categories are proposed such as "scrublands" (GoI 2005). As per Wasteland Atlas of India, scrubland refers to "land prone to soil erosion that contains some vegetative cover but cannot presently support agriculture" (GoI 2005). The 2010 edition of the atlas again differentiate scrubland into "dense" and "open" to categorise scrubland on the basis of productivity (GoI 2010). Dense scrubs have potential of intermixing of crops with local vegetation. Opposite to dense scrubs, open scrubs have thinner soil which results in less vegetation and inhibits chances of intermixing.

Table 2.1 shows the categorisation of wasteland in India. In table 2.1, the main categories of wastelands are enlisted. Some of the categories have sub-categories based on degree of effect such as degree of salinity or degradation as low, medium, strong, seasonal and permanent. The Wasteland Atlas of India (2010) also categorises non-probable wastelands for 2015-2016, viz. built up, industrial area, cropland, plantation, forest dense/open, grasslands and waterbodies (GoI 2010). Further, it estimates 5,57,665.51 square kilometre of wastelands which is 16.69 per cent of total geographical area of the country. The atlas reports that during

the assessment period 14536 square kilometre of wastelands are converted into non-wastelands. As per the report this reduction in wasteland is observed in waterlogged and marshy land, dense scrub, sandy, ravenous land and degraded pastures/grazing lands categories.

Table 2.1: Categories of wasteland, Wasteland Atlas of India 2010

S.No.	Category
1	Gullied and/or ravenous land
2	Land with dense scrub
3	Land with open scrub
4	Waterlogged and marshy land
5	Land affected by salinity/alkalinity
6	Shifting cultivation current Jhoom
7	Shifting cultivation abandoned Jhoom
8	Under-utilised/degraded forest (scrub domain)
9	Under-utilised/degraded forest (Agriculture)
10	Degraded pastures/grazing land
11	Degraded land under plantation crop
12	Sands (under riverine, coastal, desertic)
13	Sands-Semi Stab
14	Mining wastelands
15	Industrial wastelands
16	Barren rocky/stony waste
17	Snow covered/glacial area

Source: The Government of India (2010)

Bhumbla and Khare (1984) review land assessment exercises employed after the commencement of social forestry programme in India. According to them seven studies were conducted by various government agencies between 1980 and 1990, and area under wasteland in India varies from 38.4 million hectares to 137 million hectares. As we have seen Wasteland Atlas of India' latest estimate of wasteland is 55.7 million hectares. With

continuous shifts in identification and categorisation of wasteland estimation, it is difficult to derive a conclusion whether area under wasteland is increasing or decreasing over the years. Wasteland policies have been both expansive and restrictive in nature. That creates a contrary situation where the state's intent is 'improvement' of wasteland by extending classification of land and obscuring concerns of communities dependent on them.

However, policy documents of the NMB and NPB do not mention any apparatus or method for categorisation of wastelands. The documents also refrain from defining wasteland for jatropha cultivation. Though the biofuel policies bank on previous categorisation evolved in earlier policy interventions related to watershed and wasteland development programme. Nevertheless, NMB and NPB capture all agricultural and forest areas which are not under cultivation including perimeters of farming field, land alongside road, railway and canal, fallow land, pasture land, public land under various ministries, and agroforestry land. Table 2.2 represents the classification of land and area targeted for jatropha cultivation.

Table 2.2: Jatropha cultivation recommendation in the National Mission on Biodiesel

Land type	Area (in lakh hectares)	Percentage of wasteland (of total wasteland)
Joint forest management, Forest land	0.3	17
Agricultural border fences	0.3	17
Agroforestry schemes	0.2	11
Culturable fallow lands	0.24	14
Integrated watershed development wastelands	0.2	11
Public lands along roads, railways, canals	0.1	6
Government designated wastelands	0.4	23
Total area allotted for jatropha cultivation	1.74	-

Total land area in India and percentage of land allotted for jatropha cultivation	**32.87**	**5**

Source: The Government of India (2003)

2.7 The National Biodiesel Mission and Generation of Biofuel Network in India

In this section we locate various actors at policy level and discuss their role in formation of biofuel policy in India. Here we focus on biofuel networks and how linkages are formed among various actors to propagate biofuel mission and policies in India. This section draws from ANT and its terminologies which have been explained in Chapter I. Formation of the networks initiates from the Committee for the Development of Biofuel constituted by the Planning commission of India in 2002. The committee presented its report in 2003 which states that:

> The rationale of taking up a major programme for the production of biofuels for blending with gasoline and diesel in our county emanates from a variety of factors. First, there is no alternative to the petroleum based fuels i.e., motor spirit or gasoline and High Speed Diesel (HSD) for the transport sector which is the major consumer of petroleum products. Secondly, biofuels are environmentally superior fuels and their use becomes compelling if the prescribed emission norms are to be achieved. Thirdly, there is need to meet the global environment concers about climate change, ensure energy security, reduce imports, generate employment for the poor and achieve a number of other objectives of the Tenth plan.
>
> (GoI 2003: ii)

The committee was entrusted with the responsibility of preparing a detailed blueprint for development of biofuels in India to address the challenges of energy, environment and rural development. The committee was responsible for identification of appropriate area and feedstock, financial support and incentives, and providing institutional infrastructure for biofuel production. The committee comprised bureaucrats, technocrats and policymakers from research organisations of national and international repute, officials from the planning commission and various ministries such as the Ministry of Petroleum and Natural Gas, Road Transport and Highways, Environment and Forest, Railways, Agriculture and Rural Development, Science and Technology, and scientists from the Indian Council of

Agricultural Research, Council of Scientific and Industrial Research, Indian Council of Forestry Research and Environment, Indian Institutes of Technology and Indian Institute of Petroleum. The committee sought to derive an extensive draft of biofuel policy, therefore it included researchers and representatives from other expertise such as the Bureau of Indian Standards, Central Pollution Control Board, National Oilseeds and Vegetable Oils Development, All India Automobile Manufacturers' Association and All India Distiller Association.

Law and Callon (1992) state, favourable outcome of an action or initiative lies in the formation of two networks, the primary and secondary, and the exchange of intermediaries between these two networks. They explain, on the one hand, the primary network is a set of relations between an actor and its neighbours, and, on the other, the relation between those neighbours. This primary network provides a conducive space, a span of time, and variety of resources in which innovation may take place. By space they mean 'negotiation space' for actors and resource refers to political, financial, and technical support available in negotiation space within the primary network. Proliferation of an initiative/project in this space leads to formation of a secondary network that in turn generates a range of intermediaries. These new generated intermediaries will pass back to the actors in primary network.

To summarise network formation process, a network comprises a primary network, a secondary network, and a negotiation space (Law and Callon 1992). If we draw analogy from this frame for the NMB, we would find the NMB was promoted by the creation of networks at national and state levels in India. The national network comprised a primary and secondary network and a negotiation space. The members of the committee were the actors who formed primary network of the national network. The structure and initiatives of the NMB were framed in the course of negotiations within them and the neighbouring actors. To ensure the success of the NMB theses actors enrolled other actors which they formed other sub-committees at the state level.

The actors who initiated biofuel mission tried to establish a network that would create a conducive frame for survival of the mission. This in turn necessitated securing required and sufficient resources from the other actors and sought their acceptance or neutrality towards the mission. The primary network of the mission enrolled members from different ministries as actors and each actor and ministry had an important role to generate negotiation space for the mission. For example, the Ministry of Railways was included in the committee because "large scale plantations of jatropha were to be grown on vast stretches of public land along railway tracks" (GoI 2003: xi). Similarly, the Ministry of Finance was involved to support the mission through funding and devise a plan that could compete with the existing fossil fuel economy. To explore the viability of jatropha as a feedstock for biodiesel production, the Indian Council of Agricultural Research and the Council of Scientific and Industrial Research were inducted. Monitoring of jatropha cultivation on joint forest land was the responsibility of the Ministry of Environment and Forests. The Ministry of Rural Development was entrusted with linking of the mission to various rural poverty alleviation programmes. The Ministry of Petroleum and Natural Gas had run experiments to check the viability of biodiesel as a fuel and ensure blending was done in collaboration with oil marketing companies. Lastly, the responsibility of the Bureau of Indian Standards was responsible for ensuring the quality and specifications of biofuel to be used in transport sector (GoI 2003).

The collaboration between the various ministries facilitated to consolidate the NMB. Various actors have different responsibilities and they drew different meanings from the defined biofuel mission. In other words, it contained a high degree of 'interpretative flexibility' (Collins 1981). The transactions within the collaboration not only shaped the mission but also the actors that entered into transaction with it. On one hand, these transactions redefined and stabilised the objectives of the National Mission on Biodiesel, and, on the other, motives, interests and meanings of different actors are associated in the shaping of the mission. The actors in the primary network especially those from the Planning Commission had a significant role in gaining the consent of the actors who showed initial unwillingness to be enrolled in the network. Hence in the process of mutual transaction the actors were not only

shaped by the networks in which they were located, they also influenced the actors they interacted with.

The NMB identified jatropha as the most suitable tree-borne oilseed for the production of biodiesel, and focused on promoting plantations of jatropha on wastelands. The mission announced that 11 million hectares of land would be planted with jatropha to produce adequate biodiesel to be blended at 20 per cent ratio with high speed diesel by 2012[3] (GoI 2003). It was proposed that the government should demonstrate the viability of the programme with all it linkages in different parts of the country and widely inform and educate the potential participants and stakeholders (ibid.). Consequently, the actors in the primary network proposed the NMB in two phases, phase I consisting of a demonstration project and phase II comprising a self-sustaining expansion of the programme leading to the production of biodiesel required by 2011-2012.

Phase I would demonstrate the viability of activities such as plantation, seed collection, oil extraction, transesterification, blending and marketing, acceptance of biodiesel as automotive fuel and the institutional arrangements would be put in place for effective implementation of the various components of the mission. According to the Planning Commission's Report (GoI 2003) this phase would commence by 2003 and would be completed by 2007, while phase II would commence in 2007 with the objective of producing a sufficient quantity of biodiesel to reach the blending target of 20 per cent by 2012. It would involve acceleration of the activities initiated during the demonstration period, converting jatropha plantations into a mass movement and result in the expansion of plantations and other connected activities across the country (ibid.).

[3] 20 percent target of blending could not be achieved in 2012. It remained at 4.7 per cent. However, recently launched Biofuel Policy of India in 2019 again sets 20 per cent blending target by 2030.
Source:https://economictimes.indiatimes.com/industry/energy/oil-gas/ethanol-blending-with-petrol-may-reach-7-2-pc-in-2018-19-season-from-4-2-last-year/articleshow/68705372.cms

The actors in the primary network proposed that the mission could succeed if they involved stakeholders who would coordinate their efforts in the planning and implementation of it. The first step was the elaboration of the primary network by creating a coordination committee at policy level. The members of this committee were headed by the Deputy Chairman of the Planning Commission and their role was to oversee the programme, formulate policy, provide necessary guidance on raising resources and effective implementation, and deal with issues of coordination and monitoring of the programme (ibid).

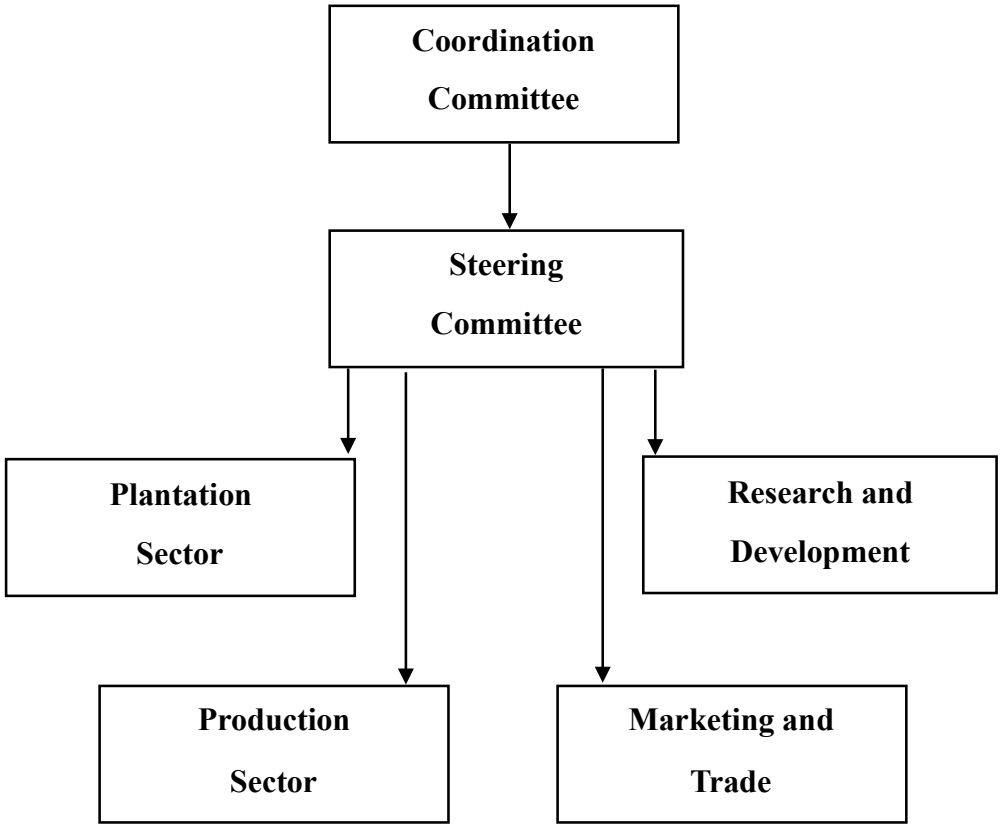
Jatropha was chosen as the viable feedstock, different ministries were enrolled, resources were made available and thereby the negotiation space had been created. The next step was to create a secondary network that would take the initiative further. The key actors in the primary network mobilised actors to form a secondary network. A steering committee was set up at the official level and a special cell was established witin the Planning Commission with the aim of serving both the committees. The actors in the steering committee formed the secondary network and comprised officials who were entrusted with the responsibility of implementing the programme by overseeing, monitoring, identifying, and solving the problems during implementation. They had to implement the decisions made by the coordination committee and subsequently keep them informed about the progress achieved and turn to them for guidance. Their key role was to advise participating ministries and organisations so as to engage effectively and efficiently (GoI 2003).

Once the members of the steering committee were mobilised, the second stage in the elaboration of the secondary network commenced. The role of the actors in the secondary network was to enrol additional stakeholders to pursue the initiative further. They envisaged the creation of four sub-committees to engage in the principal sectors of plantation, production, marketing and trade, and research and development. Figure 2.2 depicts a schematic representation of the primary institutional networking of the NMB.

The actors in the primary network had agreed that the demonstration phase would be carried out in a mission trial mode. It entailed that there would be six micro-missions that would

undertake activities such as plantation, procurement of seed and extraction of oil, processing of seed oil into biodiesel (transesterification), blending and marketing, and research and development (GoI 2003). These six missions had to be implemented and carried out by the actors of the four sub-committees responsible for plantation, production, marketing and trade, and research and development (as shown in Figure 2.2).

Figure 2.2: Primary institutional network of the National Mission on Biodiesel



Source: The Government of India (2003)

The sub-committee on plantation was entrusted with four micro-missions. The first micro-mission involved cultivation of jatropha on forest land. After deliberations among the actors it was agreed that plantation would be carried out initially across four states covering a total area of 2 lakh hectares with the collaboration of the joint forestry management committees (JFM) forest department agencies (FDA), the Ministry of Environment and Forest (MoEF), and the state governments acting as the nodal agencies to oversee the activities.

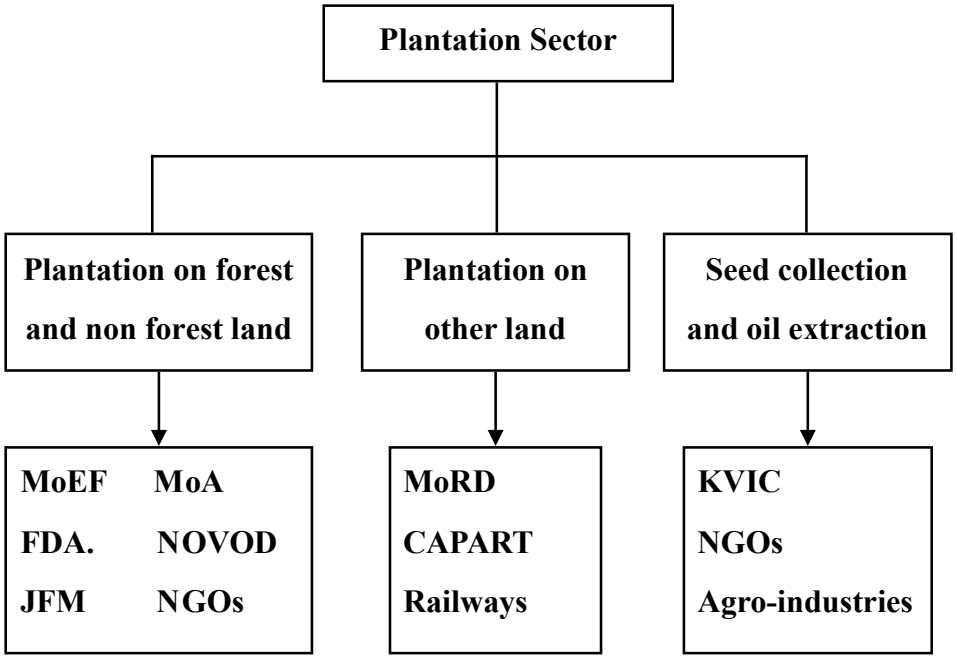
The second micro-mission dealt with plantations on non-forest lands across four other states covering an area of 2 lakh hectares. It included plantations on marginal lands of farmers, public lands along roads and highways, and canals and railway tracks, which would be undertaken by NGOs, self-help groups and user groups, cooperatives, public and private sector corporations. The National Oilseeds and Vegetable Oil Development Board (NOVOD) being the nodal agency would implement the activities of this mission with the help of voluntary organisations (VO), state agricultural universities, public undertakings, government departments and the Indian Council of Agricultural Research (ICAR) institutions, while the entire micro-mission was overseen by the Ministry of Agriculture (MoA) (ibid.).

The third micro-mission covered plantation on other lands—degraded and wastelands across the country. The MoRD was entrusted with this mission as jatropha plantations assured positive significance towards poverty alleviation and ameliorating land resources. The Department of Rural Development (DoRD), Department of Land Resources (DoLR), and Council for the Advancement of People's Action and Rural Technology (CAPART) were the main departments under the MoRD entrusted with the implementation of this mission. It was concurred that jatropha plantations would be placed under various programmes of the MoRD that were already being undertaken to help farmers to enhance their livelihoods (ibid.). The fourth micro-mission to be implemented by the Khadi and Village Industries Commission (KVIC) encompassed seed procurement and oil production. KVIC would collaborate with small-scale industries and rural agro-industries in setting up seed procurement centres and installing oil expelling units. The nodal agencies of these micro-missions were the key actors who reported to the sub-committee on plantation and acted as spokespersons for the principal actors.

Figure 2.3 is a representation of the institutional networking under the plantation sector. The arrows in the diagram begin from the plantation sector and are linked to the three sectors below and then each sector has a uni-directional arrow linking it to its constituent agency. The exchange of intermediaries between the actors was complex and messy as shown by the

bent, flexible dotted arrows. While deliberating and resolving the areas under forest, non-forest, and other land to be planted with jatropha at the planning stage, it appeared that each organisation could do it independently without interfering with the other. However, it was not as easy as it appeared, most of the time the areas under different categories overlapped. Hence the nodal agencies and the organisations associated with one area interacted with other nodal agencies and their organisations which resulted in new linkages being formed. In this manner a simple linear institutional network was transformed into a conjoined complex web as depicted in Figure 2.3.

Figure 2.3: Institutional network of jatropha plantation sector

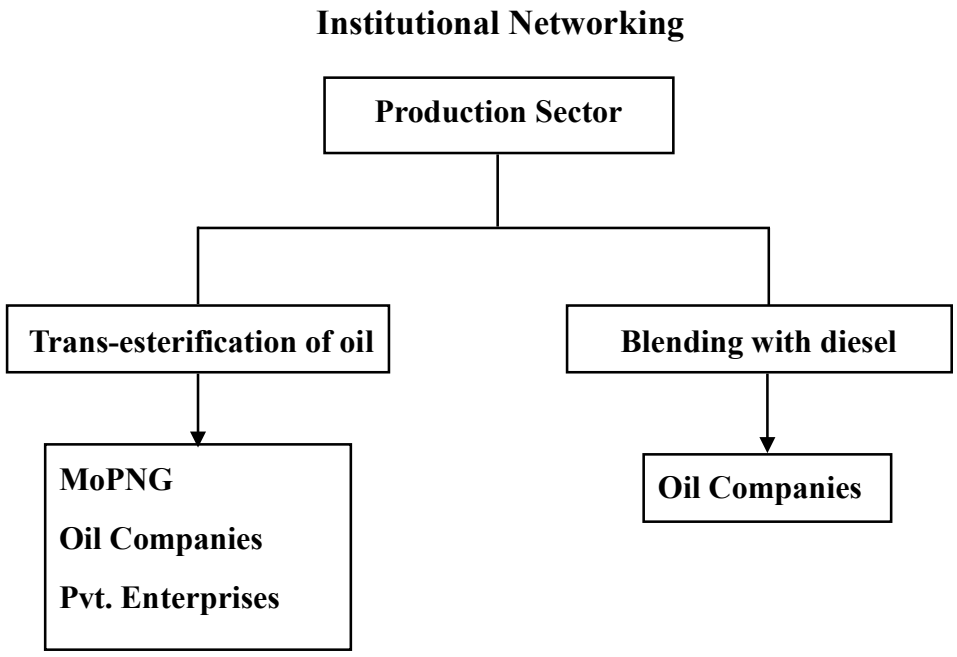


Source: The Government of India (2003)

The first four micro-missions were addressed by the sub-committee members of the plantation sector. The fifth micro-mission which covered transesterification, blending and trade of biodiesel was administered by the sub-committees on production, and marketing and trade. The processes dealing with the production of biodiesel and ensuring blending with high speed diesel were pursued by the Ministry of Petroleum and Natural Gases (MoPNG). The oil companies were the key actors who had to ensure that biodiesel was being blended

with high speed diesel and their activities were monitored by the MoPNG. The oil companies had to establish facilities that would ensure blending processes were in place or had to encourage private enterprises to do so. Once blending had been achieved the second part of the micro-mission covered the aspect of marketing biodiesel blended diesel. This activity was proposed as an organised trade activity to be implemented by the oil companies in conjunction with the Bureau of Indian Standards (BIS) which had to check the standard of the biodiesel being sold. As this micro-mission encompassed two sub-committees to impart the activities under it, two different institutional networks were set up as depicted in Figures 2.4 and 2.5.

Figure 2.4: Institutional network of jatropha production sector

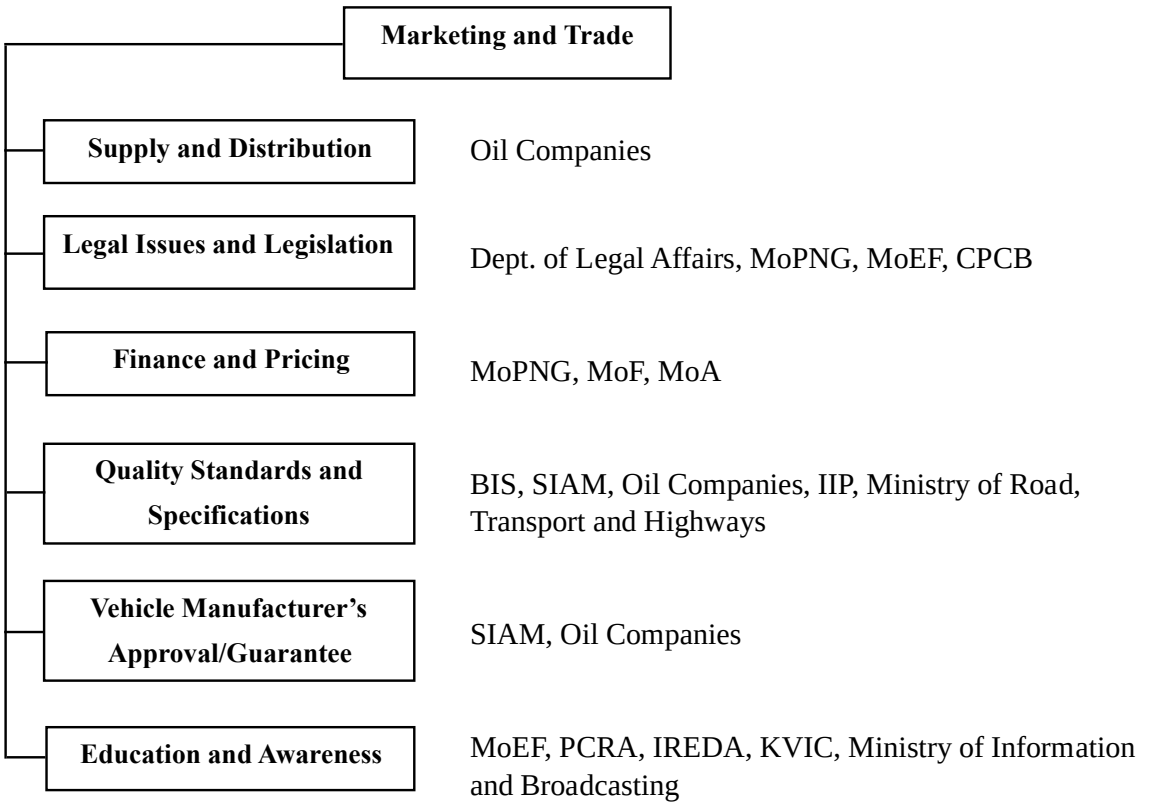


Source: The Government of India (2003)

As depicted in Figure 2.4 the production sector was primarily involved in transesterification of oil and blending. However, the network of the sub-committee on marketing and trade has involved in the creation of another level with smaller committees which handled issues of supply and distribution, legal issues and legislations, finances and pricing, quality standards,

vehicle manufacturers and approval guarantee and education and awareness (see figure 2.5) (GoI 2003).

Figure 2.5: Institutional network of jatropha marketing and trade sector



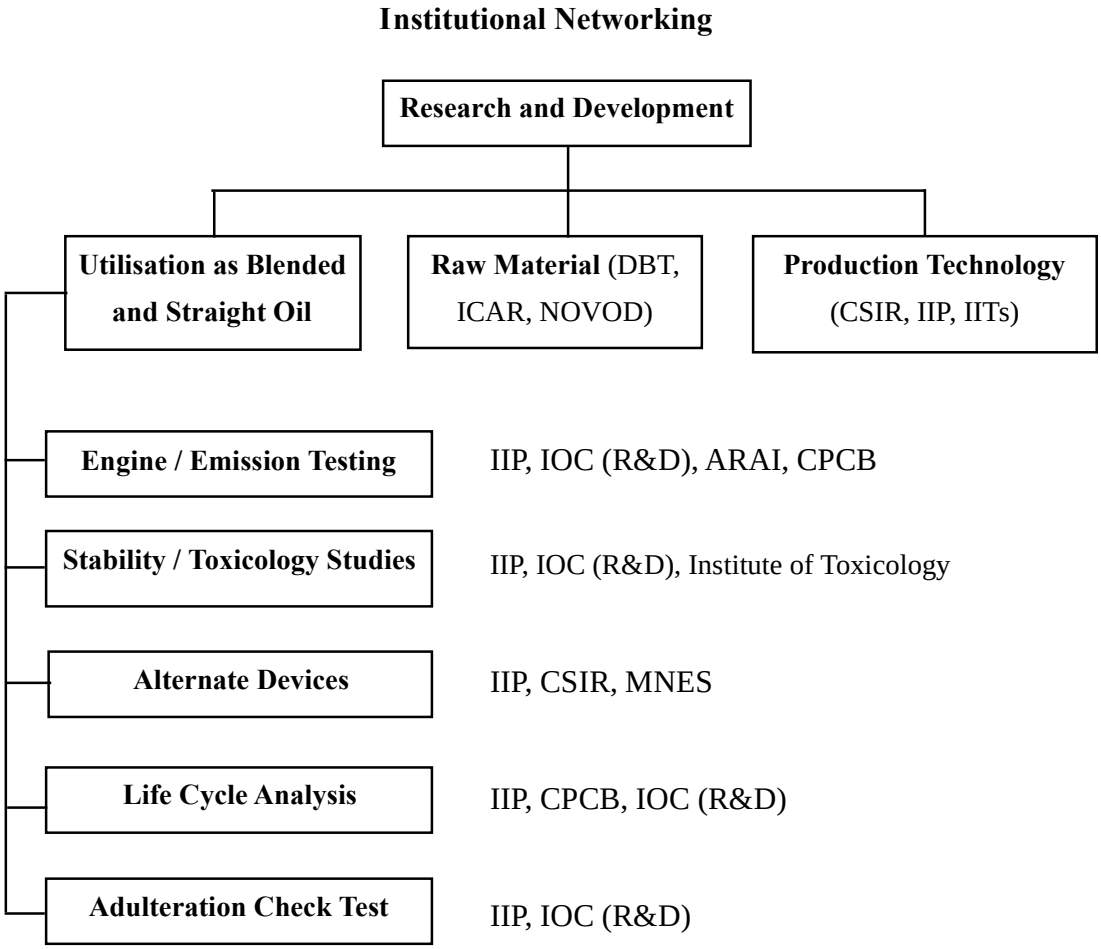
Source: The Government of India (2003)

Biodiesel has been produced in the EU and the USA from edible oilseeds whereas India was going to produce it from a non-edible oilseed, hence the sixth micro-mission was committed to carrying out Research and Development (R&D) on jatropha as a viable oilseed for the production of biodiesel. The CSIR was the nodal agency to coordinate the R&D institutions at an academic and industrial level. The key R&D issues to be addressed related to raw material, production technology, and utilisation as fuel. The Department of Biotechnology (DBT), ICAR, and NOVOD directed the research on producing improved quality of feedstock, developing agro-technologies for varying agro-climatic regions, and analysing potential non-edible oilseeds. The CSIR, the Indian Institute of Petroleum (IIP), and private

sector, viz. Reliance, D1 Oil and Emami, conducted research on efficient chemical and bio-chemical processes of oil production and utilisation of by-products generated during the production process.

Utilisation of biodiesel as a blended and straight oil involved setting up committees on engine/emission testing, stability/toxicology studies, life cycle analysis (LCA), use of alternate devices, and adulteration checks which involved actors from the Ministry of Non-Conventional Energy Sources (MNES), Institute of Toxicology, Indian Oil Corporation (IOC), Central Pollution Control Board (CPCB), CSIR, and IIP. Figure 2.6 illustrates the institutions involved under the sub-committee on research and development.

Figure 2.6: Institutional network of jatropha research and development sector



Source: The Government of India (2003)

The six micro-missions mentioned above constituted the demonstration phase that aimed to establish the feasibility of producing and blending biodiesel in India. The second phase was a self-expansion of the activities initiated in phase I to produce sufficient quantity of biodiesel to be blended at 20 per cent by 2012. It was reckoned that as the necessary networks were already in place the second phase would be easier to implement and would turn into a mass movement to produce biodiesel.

Similarly, the primary and secondary networks were formed at the state level to promote biofuel programme. For example, the Government of Andhra Pradesh established a specialised department namely the Rain Shadow Areas Development Department with an objective to uplift the rural poor in the low rainfall areas. A total of ten districts were identified as rain shadow districts in Andhra Pradesh. The government sought to amalgamate the requirement of biofuel production with the upliftment of resource poor farmers in the rains shadow districts of the state by encouraging mass propagation of jatropha, pongamia and simarouba trees among the target farmers. The department has initiated a research and development project so as to give preliminary inputs on the availability, agro-techniques to be followed and optimisation of oil extraction protocol. Under this initiative, apart from on-station experiments, on-farm trials were also taken up in ten rain shadow districts of the state.

For research and development sector, which is the secondary network, at the state level the consortium of research and development projects involved research organisations located at Hyderabad, such as, National Bureau of Pant Genetic Resources (NBPGR), Central Research Institute for Dryland Agriculture (CRIDA), Directorate of Oilseeds Research (DOR), Indian Institute of Chemical Technology (IICT), International Crop Research Institute for Semi-Arid Tropics (ICRISAT), and Acharya N G Ranga Agricultural University, which also was the coordinating agency.

Three of the consortium partners, NBPGR, CRIDA and DOR, have developed a minimal descriptors of jatropha. It deals with the important traits, which distinguish the individual plants phenotypically. The descriptors were developed based on the documentation of the

diversity more than 400 accessions of jatropha collected from all over India and established in a germ plasm block at NBPGR and CRIDA.

The actors in the primary and secondary network are heterogeneous and the way they relate or exchange intermediaries can be problematic and the manner in which they are connected determines the trajectory and success of a project (Latour 2005). The preceding discussion used data from the official documentation of the Planning Commission's Report on Biofuel (GoI 2003) to describe the creation of the networks that resulted in the implementation of the NMB. The discussion traced the creation of the policy networks at the central level, introduced the actors, highlighted how the primary actors enrolled a range of actors and mobilised them into the NMB. The section drew from Law, Callon, and Latour's work on networks to explain the creation of primary and secondary networks, how information was exchanged between the actors, how the key actors were tied in the interests of other actors, enrolled them successfully into the NMB and in turn stabilised their interests.

2.8 Land Management and Emergence of a Biofuel Crop

Implements of development often employ with bi-lateral agreement or in corroboration with global funding agencies like the United Nations or the World Bank keeping international development interests in the agenda. To depict the role of world funding agencies and jatropha cultivation in India, the following discussion synthesises the responses of the scientific community over the adoption of jatropha as biofuels crop. Here we attempt to locate the emergence of a crop from a practice of land management to a potential source of biofuels. Here we argue that the idea of "land improvement" (Arnold 2005) gave the passage for emergence of a biofuels crop in India, not the urge for biofuels itself.

Initially Jatropha was adopted as a crop for 'improvement' of land by a research institute supported by the Government of India. The western part of India with lesser rainfall has very less intensity of vegetation and researches were trying to 'improve' the condition of the landscape by adopting some measures. These measures were searching for the plant with specific characteristics which could sustain in semi-arid region with low water requirement that could withhold soil from erosion, should be able to improve the nutrients level of the

soil, and have a considerable life span. This searching task was executed by the Council of Scientific and Industrial Research (CSIR) sponsored Central Salt and Marine Chemicals Research Institute (CSMCRI)—Bhavnagar, India. The scientists identified jatropha and pongamia plants having the characteristics to grow in wasteland and simultaneously improve the land. Later, jatropha was planted in Gujrat—Western India, and Odisha—Eastern India with the funding of the United Nations Development Program (UNDP) in 1996. The results of plantation were optimistic for future coverage on other part of semi-arid regions of India.

Meanwhile, some state governments, oil marketing companies and research organisations started taking the interest in jatropha promotion. Daimler-Chrysler used the oil in Mercedes Benz and ran about 10000 km and was satisfied with engine performance. The D1 oil, a UK oil firm, collaborated with CSMCRI and the Government of Chhattisgarh for oil processing and distribution, and various other state governments proposed enthusiastic plans for the plantation, promotion and distribution. The CSMCRI received funds from the UNDP to cultivate jatropha at modest scale. But, the intention of plantation was not for biofuels, rather to 'improve' coastal areas, sand dunes and 'wastelands'. Later it was followed by appropriation of land after the improvement. Nonetheless, the fact that jatropha lived up to its reputation as a shrub that could survive relatively on 'barren' land stimulated the interest of India's Department of Biotechnology, which provided a modest funding for further exploration of biofuels possibilities using cuttings from three of the most productive plants – Navsari, Chhatrapati and Hansraj – in the UNDP trial. These developments also attracted the investors from outside India. A fund of US$1.9 million started research on Jatropha, which comprised of grants from Daimler-Chrysler AG, the German Investment and Development Company in Cologne, India's Council of Scientific and Industrial Research and the University of Hohenheim (Fairless 2007).

Identification of jatropha as a potential plant for land improvement and subsequently as a biofuel crop seems uncontested from the above paragraph. However, in the same CSMCRI laboratories other plants were also in consideration for land management. In the words of one of the scientists from CSMCRI:

> There are other plants which are economical, important and commercially viable. Such as jojoba (scientific name: Simmondsia chinensis). It grows very well in sand dunes and it has high commercial values. The cost of per litre of its oil varies from Rs. 3000 to 30000. It is used as an alternative of span-well oil which is endangered now, which has cosmetics value. There there are different types of land. For these lands different types of plants can be used. Like in the Kutch area jojoba plant is very effective. If we take saline soil there are different ways, suppose if you want to green some area then grow Salvador. This is a tree type plant, and its oil is very important and it grows very well in high saline condition. Second is Attriplux Nemelenia, it is not an Indian plant. We have collected some seeds of Attriplux Nemelenia from other countries and planted here. It absorbs salt from the soil. So, it can be grown for greening purpose on the land which has high salinity. Vegetation is required for environment, for barren land, and if you plant something over there, it definitely helps microbial flora fauna and also provides shelter to animals of the area. It also helps to reduce environmental pollution and soil erosion.

Soil erosion, vegetation, greening a land, barren land, pollution, environmental and economic viability are the concerns which are present in the above quote of a scientist from the CSMCRI. To identify the underlying reason(s) of jatropha's selection over other plants within the research institute may lead to a possibility of error. Rather, selection of jatropha and impetus given to its cultivation have contentious political underpinnings. On one hand, it involves the politics of land, food and energy, and, on the other, it is embedded with elements of local and global crisis narratives, mandates of funding agencies and institutions.

Where CSMCRI focusses on land management and selection of a biofuel crop, Chhattisgarh Biofuel Development Authority's (CBDA) mandate is promotion of biofuel. The CBDA is a statutory body formed by the state of Chhattisgarh in 2005 for production and promotion of biofuel by jatropha. The CBDA is one of the prominent bodies formed just after the recommendation of the Planning Commission of India in 2003 under the wider guise of diversification of crude oil import to domestic production of biofuels in rural settings so that the burden on foreign reserves can be reduced (GoI 2003).

The CBDA authorised four departments for identification of such lands, namely, departments of forest, horticulture, agriculture, and *Van Vikas Nigam* (forest development council). Each of these departments are allocated funds for specific task. The horticulture

department develops the nurseries for jatropha plants, the plantation is done by the forest and agriculture departments, and *van vikas nigam* is responsible for maintaining the plantation and pluck out fruits for further processing (Source: Field Study). Though CBDA seems to collaborate with the other departments and stakeholders. The interaction with the farming community appears secondary. In the words of from an official from CBDA:

> State forest department is our major stakeholder, they select the site and ask our support for plantation technology as per the local requirement. And yes, farming community, they are also our stakeholders. If the objective is to reclaim the site then preference is given to leguminous trees rather than fodder or other bushes.

The Planning Commission Report (GoI 2003) also hopes to improve the socioeconomic condition of rural areas by reducing dependency on oil imported from other countries. With these motives CBDA started marking wastelands in Chhattisgarh and cultivating jatropha on them. One of the officials from CBDA elaborates:

> India has large areas of wastelands. In Chhattisgarh as well, around thirty percent area of total land is wasteland, which is available with proportion to population of the state. It can be a revenue land, barren land, grazing land, etc. In initial phase we experimented in different varieties of soil, along railway tracks, on the bank of canals and ponds. Total area covered was around 1,50,000 hectares. We made some clauses as well, like the plantation will not be carried in urban areas and beyond 5 km periphery of rural areas. But later on, encroachment of these planted areas was started by local people. Some villages also objected about grazing land, that their cattle are not getting sufficient space for grazing.

Oft-repeated understanding of a land which supposedly needs improvement is evident in CBDA authorities. The official not only emphasises on abundant availability of wasteland in the state but also includes other land which may be fertile and be in use for the local communities. Ironically, CBDA perceives the local community as an encroacher of the land.

At the global level, jatropha is promoted as a probable blending oil or most probable replacement of diesel, considered a renewable source of energy in the wake of depleting fossil fuels, a savior to follow global mandates on reducing greenhouse gas (GHG) emissions. At the local level, the Government of India considering all aforementioned global

benefits of jatropha, envisaged the rural development through employment generation, poverty alleviation and better land management. Biofuels policy documents—National Mission on Biodiesel 2003 and National Policy on Biofuels 2009—clearly depict the plans and proposals for setting biofuel complex as a medium of rural development where preference is being given to jatropha than other oil bearing plants, and crops proposed for ethanol production (GoI 2009).

As per the National Policy on Biofuels (NPB) there are over 400 species of trees bearing non-edible oilseeds in India (ibid.). The potential of all these species claimed to be considered, depending on their techno economic viability for production of biofuels. It has been possible to identify jatropha as the "most suitable tree borne oilseed for production of bio-diesel in view of its ability to thrive under a variety of agro-climatic conditions, low gestation period and higher seed yield" (GoI 2009:7).

On the aspect of selection of jatropha among other considered species for biofuel feedstock can be understood in the words of a scientist from ICAR- sponsored National Bureau of Plant Genetics, Hyderabad. She elaborates:

> We had taken a project, where we tried to screen out some tree borne oils, like jatropha and pongamia are the tree-borne oil. Which can give yield for 30 to 40 years. So we are trying to screen forest based sources, along with the forest department. We are also trying to see that are there plants for edible purpose, or an appropriate oil for biodiesel, or an appropriate oil for industry, then we want to introduce that particular seeds which can be grown just like in the forest. If one look at the potential of these plants and wants to propagate in his or her land, it might really produce more oil. We need to look at the appropriate crop for the appropriate land. As a common person, what I feel that we are not managing our land properly.

Similarly, a scientist from the Centre for Social Forestry and Eco-Rehabilitation, Allahabad, opines:

> Initially they [The Planning Commission of India] asked in 2002 to collaborate with NOVOD board for trial on some plants like jatropha, neem, pongamia. Simaroba, mahua. Later they asked to focus only on

> jatropha. In later phases focus was on developing networking centres for seed exchange, degraded site restoration, like at Shankargarh. But in our trial fields farmers did not take interest in tree like bushes, they were more interested in big trees.

Though jatropha came out as the sole crop to be cultivated under the NMB some locations reported not so optimistic performance of jatropha in the initial phase of plantation. Owing to the fact that jatropha was promoted under blanket policy all across the country and biophysical conditions of the location were ignored while framing the NMB. However, a few scientists interviewed in this study are not so assertive on the selection of jatropha as the only crop for biofuel feedstock, they do present a choice alternate to jatropha. For example, one of the scientists from ICAR-sponsored Directorate of Oilseed Research, Hyderabad, suggests:

> After jatropha these people talked about pongamia. Pongamia also has the same problem, and if you see, the processing of oil extraction is different with pongamia. If you compare jatropha and pongamia's fruit, the layer is thick in pongamia. It requires more labour and processing steps, and does not have that much of oil content as compared to jatropha which has 35-40 per cent of oil. Then, why it should be preferred? It is native to India, its leguminous plant so it fixes nitrogen. We have lot of variability of pongamia in our country. These are the reasons why people are promoting pongamia. But it is tall tree how much you can promote it. It does not have deciduous nature like jatropha to bring back nutrients to soil.

Exotic varieties of jatropha were introduced from South American countries (Dias et al. 2012). A few scientists in India engaged in research in variety development of jatropha also see this as a reason of not having ranging varieties of jatropha in the country. A scientist from the University of Delhi proclaims:

> Another aspect is that why we could not achieve what was expected. The major reason was that normally what happens we prepare a policy after having a lot of experience for a particular project; in this case there was not much time when policy came and there was not much background information available as well. ThoughjJatropha was introduced in late 1970s and all of sudden again it was reintroduced in 2002-2003, this huge gap lead to under growth of jatropha and at that time [2002] there was no dedicated funding available for conducting R&D in this area. The projects offered to the scientists were also very short term, to develop a variety for any crop it requires at least 10-12 years. With such short

> duration project, one should not expect desirable results; therefore we could not go beyond certain limit. The third reason was that there was very established network for collection of the germplasm, but ultimately it has been found beyond a limit yields were not going up and indeed the yields were not consistent. In our R&D also there have been instances of experimental positive achievement, but we could not demonstrate in large scale field cultivation, and this the same with other R&D centers like CSIR, DRDO labs.

If we combine the perceptions of the scientific community either on the selection of jatropha over other plants or the possibility of other plants with jatropha for biofuel production, a thick consensus among them seems to be formed which aligns them with the biofuel policies in India. However, this is not the case always. A senior scientist from CSIR-sponsored Indian Institute of Chemical Technology, Hyderabad, criticises the biofuel policy's initiatives. He expresses doubt on approaches adopted for the selection of feedstock:

> In the process people thought jatropha does not require water, it does not attract pest. So, thinking like that, they did not do lot of research, they just went to several forest, they picked up some of the seeds, they analysed oil content in those seeds, they got 40 per cent of oil, they thought it is an extraordinary seed, they came and they really planted that one. Finally, without water these jatropha plants could not grow. And most of the plants attacked by pesticides. Whatever people really assumed, which was not correct. So ever after 5 years of plantation several of them did not give the seeds. That is the reason, why jatropha in most parts of the country people are abandoning it. According to me, we did not do proper groundwork before identifying jatropha as an appropriate plantation. Without putting water and and care, you can become overnight millionaire, during the process they really killed the sentiments and dreams of several farmers.

The NPB claims that the Indian approach to biofuels is different from current international approaches. It expects that international approaches may lead to conflict with food security. On contrary, the Indian approach is "based solely on non-food feedstocks to be raised on degraded or wastelands that are not suited to agriculture, thus avoiding a possible conflict of fuel vs. food security" (GoI 2009:3). The biodiesel initiative was promoted by the GoI as a 'pro-poor' initiative that would use 'wastelands' for the cultivation of jatropha (GoI 2003).

The goals and claims of the biodiesel mission seem unproblematic in policy documents, and moreover many of the respondents in this study, especially among the scientific community,

do agree with the claims made in the policy documents. However, this is not the case when a technology is deployed in the sites, and the site becomes the place of contest and conflict. To present the agreement of scientific community who align with the biofuel policy, we will take a few examples on the claims pertinent to wastelands and suitability of jatropha plant for the same. For example, according to one of the scientists from CSIR-sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar:

> Land management is about selection of wasteland. There are various kinds of wasteland, viz. saline wasteland, rocky wasteland, water-logged land, frosty land etc. Any sort of land with inherent problem and limitations where you cannot grow normal arable crop. We do not want which is giving vey vegetative growth. We want some balanced plant which can give some vegetative growth and more of reproductive seeds. We have developed some techniques, where vegetative growth can be diminished and the same time seed yield got increased. Definitely, developing plantation for land management is very must, because it helps environmentally as well as for land itself.

Another scientist from the same research institute adds to the suitability of jatropha for wastelands:

> Jatropha curcas is very good plant for wasteland, but there is a myth that jatropha produces a good number of seeds. Though it can grow very luxuriantly in wasteland, rocky land and other different kind of land. We have tasted this in all over the country, it grows very well. But what happens, it also requires a good amount of inputs in the form of water and nutrients for healthy and good production. We are targeting on the wastelands where nothing else grows. Jatropha has the capacity to grow in such lands, provided you amend the soil well, means a deep digging is required through heavy machinery once in a life-time. If you just plant, it will not bear expected quantity of fruits. Essential requirement is how to manage the root-zone. So, there is a limitation with the plant. If you do not want any production it is good, but if you want good production you have to plant some selected one. It requires elite plants, then only you can get good production.

It can be inferred from the views of the above scientists that wasteland is land where nothing can be grown. The land cannot be used for growing crop, tree plantation, or developing it as a forest. Similarly, the land which is empty is considered wasteland such as the land alongside railway tracks is targeted as wasteland in the NPB and to cover the parallel areas of track with greenery jatropha plantation is proposed (GoI 2009). The definition of

wasteland in India is contested. The rural farmers and labourers questioned the classification of land as 'wasteland' and 'unused' and were against the cultivation of jatropha on the common property resources (Baka 2014).

After being criticised for misinterpretation of wasteland in the policy documents, policymakers and scientists took a turn and promoted jatropha for land management. By land management they imply that the land which is poor in nutrients and have limited scope for agricultural purpose. A scientist from ICAR-sponsored Directorate of Oilseed Research, Hyderabad, sees land management in terms of limitation of a land to grow certain staple crops:

> In India we have very small land holdings, and majority of them are small and marginal farmers. When we talk about jatropha which is suitable for arid and semi-arid region in dry tropics, then you have to aim at small and marginal farmers only because we cannot have rice, wheat, pulses etc. If some cropping system is there then, or everywhere and wherever we have other crops, we cannot inject jatropha. Only thing is that the 70 per cent is rainfed agricultural area in India, in that also what is not suitable for other crops we have to target those regions only. Again, majority is marginal farmers so any crop should not be pushed.

Respondents from the University of Agricultural Sciences, Bengaluru, doubt over classifying land as a wasteland and forcing the farmers for plantation in such land which is available with them or in their vicinity. Their concern is:

> The available land could be yearly marked for agriculture and for the trees, few trees not large plantation. There should be no force for farmers to grow more number of trees…We do not advocate plantation, because the species we are talking about [jatropha] take long gestation period, at least three years. So what service will they get up to three to four years? It should not come in the way of agriculture, since the plants are closely nested. If, other benefits can be drawn like soil conservation, moisture retention and so on, we can propose some plantation. So, once they start yielding other benefits will be there for agriculture. We do not expect them [farmers] to engage in plantation only, because they may get idle, because they have to wait for the harvest season and income during the harvest season may not commensurate with what they have done, they may get more or they may get less. What is important for us is: food production. For this land should not be converted to biofuels plantation.

Essentially, land is a part of a production system of a country. It gives, with sunshine and precipitation, a production system for growth for living creatures. With inputs like nutrients and micro-nutrients provided in the soil and symbiosis with the micro-organism in the soil, it produces manure. Land management is to tap energy, convert and conserve it for the organisation of agricultural production system. Prima facie the output from a plant is a fuel, the food is fuel from where we get the energy. The main function of photosynthesis process of any plant is to store energy. Therefore, the fuel is that grade of energy which does not have other higher values. Land management is also related with the amount of mechanical inputs that a land gets, subject to availability and limitations of technology in hand or use. It could be just labour or combination of labour and externally energised devices. One of the scientists from the Indian Institute of Science, Bengaluru, relates the land management and labour's skill:

> Depending upon unskilled labour to highly skilled labour, the amount of land one can cultivate is determined by the limit of labour. For example, somebody is cultivating the mulberry, a family can manage this crop moderately; more than that will require extra labour and support. So, the amount of land one can cultivate depends on combination of labour and technological inputs of the cultivation. We have best land resources in the world. The land availability is lot more than what we need, to make absorb the available labour. So in that case, you use a portion of the land which can absorb this labour, so they can be employed. And the remaining land can be used for the perennial crops, either bushes or trees, which once planted can be sustained for decades. So that photosynthetic potential of the land can used for the carbon sequestration and other purposes.

One of the participants from the Karnataka State Biofuel Development Board perceives land management in terms of accessibility, capacity, and usability of land. According to him:

> Land management is a critical issue because of land acquisition by the governments for industrial purposes, real estate, and other developmental activities. Either we can purchase, or we cannot ask from the government to do this program [of biofuel crop plantation]. That is why we are working with the farmers. Wherever the low-density forest area or wasteland is available, means nothing can be grown in such lands, biofuels plants like pongamia, neem, jatropha etc. can be grown there. You just have to take care of these plants only

> for two summers. You have to give some water during the summer, after that they can survive on their own. Moreover one must not forget the carrying capacity of the particular land. Jatropha is a bush type plant. Based on the carrying capacity of the land, it is planted in those land which has low fertility, as far as the biofuel policy is concerned.

There are various countries who are in the advanced stage of biofuel production from corn, sugarcane and palm oil such as Brazil, the USA, the EU. India opted a different approach for biofuels as mentioned in the NMB where non-agricultural land is preferred to avoid conflict with food crops. A senior scientist from the Indian Council of Agricultural Research align with the policy and explains:

> Why we went ahead with tree borne oilseeds? From these debates or from the problems other countries are facing, a lesson learned from others' experiences and we framed our biofuel policy in different line. There are two points which are clearly mentioned in the policy: a) we should not go for food crops, e.g. soybeans, corn, etc for biofuel production, and b) we cannot target the prime agricultural land. For the purpose degrade land, problem/marginal soil land are to be targeted to avoid the conflict between agricultural land and biofuel feedstock.

Perhaps, this is the reason why biofuel crop plantation received much attention in the initial stage. This reception has similarities with the experience of eucalyptus plantation from Punjab, Haryana and western UP where farmers gave preference to eucalyptus over food crops to gain more profit. Therefore, in the biofuel policy it is clearly mentioned that one cannot cultivate biofuel crop in their agricultural land.

On the one hand, whereas a few scientists seek for the policy recommendations and support for the plantation in wasteland, on the other, a group of scientists see this as a limitation of the policy. A scientist from the University of Delhi comments:

> The so called land which we identified for jatropha plantation was estimated around 11 million hectare in the policy, but could not get those land. That is how this mechanism could not work. There was greater focus from private sector but they also could not materialize what they expected in terms of land availability and production thereafter. There was lack interaction between the ministries who

were responsible for deliberating different task like Ministry of New and Renewable Energy, [Ministry of] Rural Development, etc.

On the contrary to promotional and limitational aspects of the biofuels policy discussed above in the context of perceptions of the scientific community, a senior scientist from the University of Agricultural Sciences, Bengaluru has a different approach for the land selection and preference of the crop for plantation. Though jatropha seems a very important for biofuel, it cannot be grown as a soul crop. He elaborates:

> For biofuels, land management and other issues, we have, what we called multi species approach, not single species. The species which are locally suited and not planted on plantation mode, because plants are being planted by farmers. So the farmers plant along the borders of their field, backyards, and it should not come the way of agriculture crop production. If they are growing a few plants, they are growing under agroforestry system. If the farm size is small, less than an acre, only two trees would be sufficient, and if the area is more, then a farmer would go for plantation mode.

In India, biofuels from the non-edible oil producing plants, which perform well under the limited resources, is seen as a potential source. The Planning Commission of India (2003) gave an impetus to the cultivation of jatropha, as it was reported to yield non-edible oil suits for biodiesel production, for its sturdy nature and multifarious uses of other parts of the plant. The commission report on the NMB (GoI 2003) attaches land management through jatropha plantation as one of the motives. However, a few scientists interviewed for this study combine the land management with environmental concerns. A scientist from the University of Hyderabad recognises the importance of jatropha as a biofuel crop in terms of:

> In Mexico what they [the scientists] have done, each one has access of the crop life cycle assessment [LCA], what a plant consumes and what goes back to the soil. Without LCA a crop cannot be grown there. In China, when you grow jatropha, it has the ability of shading graze. It is deciduous and it a perennial crop, so in initial one or two year on has to manage the crop, then government handover the crop to people to maintain. Here the deciduous nature of the plant used to make land more fertile and make the land arable, here purpose was different. In Mexico, one need 3x3 square meters of spacing for jatropha, continues pruning is required, without pruning yield will not be good. they have tapped the inter-spaces, some medicinal plants need shades/protection from

direct sun light. This way they got market for the two crops medicinal and biofuels.

2.9 Differing Perceptions on the Emergence of Biofuels in India

In the previous section we traced the trajectory of jatropha as a feedstock for biofuel program in India, and its significance in the land management. In this section we attempt to present a few cases where a few scientists have stark contrary perceptions regarding the necessity, emergence, and selection of feedstock claimed and promoted in the India's biofuel mission and policies.

Below here is the excerpt of the interviews[4], here we try to juxtapose these cases and response of the previous participants, to draw a broader picture and to understand the politics of biofuel at local level, and how it is influenced by global politics of biofuels.

One of the scientists from CSIR-sponsored Indian Institute of Chemical Technology, Hyderabad, questions the thrust given to biofuel over other edible crops. The respondent points out lacuna in the identification of land and appropriate crop for that particular land. This scenario leads to diversion of land resources and affects the food and fuel basket of India. The respondent emphasises on cultivation of edible oil crops over biofuels crops such as jatropha.

> What general comment I can make for the land management, as we are not agricultural scientists. I do not have any right to criticise any policy or somebody. I am not criticising anybody. Basically what I feel, we do not have proper "scientific audit" for land management with resort to selection of crops with appropriate land. For example, a particular land may give you a lot of yield of x-crop, but in several places because of maturity, lack of knowledge, instead of growing x, they grow y. During this problem what really happens: the farmers do not get their input cost forget about the proper benefit, and therefore, the country is not getting proper resources. This is my personal opinion. Say in Malaysia, they are producing 20 million tonnes of palm oil from 6 to 7 million hectares of land. Whereas in India, from 29 million hectares of land we are producing only 8.5 million tonnes of vegetable oils. If India really want to go in similar line, we have to look at the appropriate crop, there is a lot of scope to

[4] The identity of the participants and their affiliation in these interviews are being kept anonymous as asked by the participants.

> produce more oil. Today we are producing 8.5 million tonnes of oil, and to feed our people you are depend on other countries. You are importing 14.5 million tonnes of different varieties of oil from countries like Malaysia, Indonesia, the USA, and Europe out of it 75 per cent of oil is palm oil. We are not self-sufficient in vegetables oils forget about the quality of oil. One should ask, why do we need biofuel in this scenario?

Another scientist from the same institute links the international trade politics and emergence of biofuels crop all over the world. The respondent is also not in favour of biofuels and suggests that only surplus edible oil should be used for biofuel production.

> Now let us see, how that would have happened? If you look at the history, the USA and others forced India to go for the General Agreement on Tariffs and Trade (GATT). This is all economics and politics, they forced us to sign the GATT. There is a big clause that you cannot give any subsidy to your farmers. The Left in India protested the GATT. They are less in numbers and nobody listened to them. And some others ridiculed them, no other big political party supported the Left in this issue. The points were raised, when the USA is giving total subsidy to its farmers, and we are going for GATT. Why we cannot give subsidy to our farmers. It has become a big mess for our farmers and our country. In the USA major oilseed crop is soybeans. In the 1980s, the USA was pushing for their crop to developing countries like India, Pakistan and Argentina. They pushed their things in these countries. And they are doing business. Whether it is palm oil, mustard oil, soybean oil, sunflower oil, you just want to cook your food and get some calories. So people will naturally go for the cheaper one. The USA has contract with their farmers, it will buy the oil. If you will browse the news of 1992-93, you will find one British ship caught the USA ship which was throwing the edible oil deep inside the sea. Because their warehouses were full. They were unable to do anything with the extra oil. Fortunately for us and unfortunately for them, passing of the British ship this was a big issue at that time. Now they cannot dispose the excess oil in the deep sea. So what to do, then they brought the biodiesel concept. Then other governments also start giving subsidies to biodiesel. As we all are the followers of the Western steps, we also started giving emphasis to biofuels. We do not have sufficient oil to eat. If I have oil to eat, I will first feed my people. Second, if I have surplus, then I can go for the biodiesel. You must have heard of Fidel Castro, he raised the voice against biofuels. He asked, which one is more preferable, food or fuel? This is the history of biodiesel internationally. When it came to India, some big-shots went for jatropha, they said without giving water, pesticides, fertilisers, it can grow anywhere, and will good yield. They never thought of the limitations of the plant, though a few studies were already there at that time. These big people did not do proper research and ignored the research findings.

2.10 Conclusion

The aim of this chapter was to locate the trajectory of jatropha— the biofuel feedstock introduced by the Government of India under the National Mission on Biodiesel in 2003 and subsequently by the National Policy on Biofuels in 2009. The government's initiatives on the biofuel policies have both the global and local influences, on the one hand, these are driven by the global energy demand pattern and, on the other, rural poverty alleviation, energy security and foreign exchequer indicates the local. In this process we situated energy policies in general and the biofuel policies in particular, in independent India within the frame of sociotechnical imaginaries. We find that the imaginaries have different connotations for the nationalist leaders which deviate from the ideal – energy for equity and justice.

In our discussion on the genealogy of wastelands in colonial and post-colonial India we argue that the classification of land into marginal or wasteland is not the first instance that surfaced with jatropha cultivation in 2003. Rather, the politics of wasteland classification has had a history of development initiatives in both colonial and post-colonial regimes. We examined the previous wasteland development programme and attempted to draw parallels to current biofuel missions and policies. Here we infer that the idea of 'land improvement' paved way for the emergence of a biofuels crop in India, not the urge for biofuels itself.

In the later part of the chapter we illustrate that for any new technology/initiative to be introduced in a country it has to be supported by a network. This section drew from ANT to outline the development of the biofuel initiative in India. Here we discussed the emergence of the biofuel network at the central level where the key actors were bureaucrats, politicians, scientists and representatives from the industry. The discussion revealed the role played by the actors from different ministries in supporting the biodiesel initiative and actively promoting it. The NMB targeted the development of biodiesel as a viable technology and cast jatropha as the most suitable oilseed for the production of biodiesel. The discourse revealed the interpretative flexibility of promoting this initiative and how various actors aligned themselves with it. Further, we move on to illustrate the perceptions of the scientific community, policymakers and officials engaged in the biofuel programme. We find the

stakeholders have differing perceptions on identification and management of land, and selection of jatropha as a feedstock, which do not often submit to the claims made in the biofuel policies.

In the following chapter we attempt to capture the materiality and agency of jatropha, discursive nature of scientific claim-making in biofuel promotion or opposition, and in turn we move on to find the presence of sociotechnical system for biofuels in India. This chapter depicts the interaction between jatropha and the scientific community in the background of diverse ways in which research and development on jatropha is carried out in social, political and technological facets.

Chapter III

Contestation—Consensus—Contestation in Scientific Claim-making: Sociotechnical Systems for Biofuels in India

Introduction

In the previous chapter we have discussed the emergence of jatropha as a feedstock for the biofuel missions in India. We sketched its trajectory from a bush for 'wasteland' to a crop for land management and 'improvement'. Jatropha was projected as a renewable source of energy and as an instrument with manifold societal benefits. It was also promoted as a hardy crop which did not require soil preparation, irrigation and fertilisers, and its resistance towards diseases. These claims and promotions were extended by the biofuel steering committee established by the Planning Commission of India (GoI 2003), which in turn led to formation of the biofuel network constitutive of various other committees and sub-committees entrusted with responsibility of exploring various facets of jatropha. Within the process of enrollment in biofuel network jatropha was in centre and had to be intervened by science and technology as planned by the committee.

Interventions of science and technology have affected jatropha in all its dimensions, such as growth characteristics of the plant, oil content and composition of other elements in the seeds, cultivation techniques, processing methods, and distribution channel. Thereby science and technology have been playing a pivotal role in shaping jatropha since it came in the purview of land management and later on biofuel network.

Against this backdrop, this chapter explores the interaction between jatropha and scientists from different perspectives. This chapter sheds light on the diverse ways in which research and development of jatropha are catered in a variety of social, political and technological contexts. This chapter under a broad canvas, corresponding to the second research question and objective of the present study, captures the responses of various actors involved in the promotion of biofuels, viz. scientific community engaged in research in biofuels from selected scientific institutions located in centre and state-funded universities and research

institutions, officials from selected state biofuels development boards, and other government and non-government organisations engaged in biofuel cultivation, production and promotion in India. In the process we aim to capture the materiality and agency of jatropha, discursive nature of scientific claim-making in biofuel promotion or opposition, and in turn we move on to find the presence of sociotechnical system for biofuels in India. To support our discussion, we mainly bank on actor-network theory though the discussion also draws from other perspectives embedded in STS studies such as Kuhn (1962) and Pickering (1992, 1995).

3.1 The Materiality and Agency of Jatropha

Material artefacts have a prominent place in the science and technology (or technoscience[5]) practices in STS scholarship that lead to the development of a number of original concepts and theoretical positions within the scholarship. These positions extend that the practices of technoscience are not intrinsically different from any other social practice. For example, actor-network theory (ANT) developed by Michel Callon and Bruno Latour (1981) and John Law (1986) rejects any fundamental distinction between human and nonhuman actors. Donna Haraway (1990) combines social, biological, and technical construct of human body and comes up with the concept of "cyborg". Sheila Jasanoff (2005) conceptualises "liminal agents" the agency of other forms of nonhuman or not yet fully human creatures. Nonetheless, ANT gives equal attention to all objects whether they be human, nonhuman, natural, cultural, real or fictional. They are all actors and try to form link with other actors to become stronger or more persuasive. As far as material objects are concerned, all kinds of material objects are dealt with by technoscience such as large and small, solid, liquid, and gaseous, living and inanimate, singular and composite (Latour and Woolgar 1979; MacKenzie and Wajcman 1999).

[5] Technoscience indicates the relational nature between science and technology. Rather than perceiving science and technology as different entity, here we understand both are co-produced. The term "technoscience" is used in our discussion as and where applicable (see Latour 1987).

However, criticism arises from traditional sociology and within the STS scholarship over the symmetry granted to human and nonhuman actors. For example, Vandenberghe (2002) criticises ANT for downgrading the importance of human beings and exaggerates the significance of nonhumans. He exclaims, there are essential differences between humans and nonhumans. Humans have intentionality and technologies have no intentionality. Fuller (2000) also thinks that ANT grants too much power to technologies. Fujimara is *"*still sociologically interested in understanding why and how some human perspectives win over others in construction of technologies*"* (cf. Star 1991: 29). Collins and Yearly's (1992) disapproval comes to defend the standard notion of sociology of scientific knowledge which states that scientists produce accounts of material agency, therefore these accounts fall into the domain of scientific knowledge and should be analysed sociologically as the product of human agents. Nevertheless, ANT responding to these criticisms explains that human and nonhuman agents interact semiotically – science of signs, which implies that the agents are coming into relations, fading away, moving around and changing places with one another, and so on. Their status can easily make the transit between being real entities and social constructs, and back again (Harman 2018).

Further, ANT comes up with the notion of "actant" which denotes that whatever *acts* or *shifts*. Latour exemplifies how the notion of social and actant interplays in a particular situation:

> When a bicycle hits a rock, it is not social. But when a cyclist crosses a 'stop' sign, it becomes social…when a hammer hits a nail, it is not social. But when the image of a hammer is crossed with that of a sickle, then it graduates to the social realm.
>
> (Latour 2005: 83)

Latour's reflection here suggests that objects are not identical with their properties, but have a tense relationship with those properties, and this very tension is responsible for the changes occurred in social relation. The properties of objects may be manifested in two forms: the one in the form of symbols and meanings, and the other in the form of real and intentional. These manifestations appear in terms of agency of an object. The former ones are implicit in a way and the later act in explicit way when objects interact with other objects.

The materiality and agency of jatropha manifest differently in different laboratory and field settings. For example, in a plant breeder's laboratory jatropha might imply a species contained in a small flask of solution that is made significant through data processing and transcription. For a life-cycle analyst jatropha's input and output during the growth make meanings. In a field experiment, jatropha's roots, stems, leaves, fruits and seeds become the concerns for scientists at various times during the growing seasons. Indeed, the influence of weather, water, fertilisers, and soil contents and organisms, which are external agents to jatropha, support in framing its materiality. When jatropha interacts with scientists, farmers, and other agencies and other actors in different settings, its materiality becomes more visible, and in turn the actors draw upon different perceptions that may appear connected or fail to connect with the presumed expectation from a commodity.

3.2 Dialectic of Resistance and Accommodation

Pickering (1992) talks about representational and performativity of science. The representational idiom casts science-as-knowledge. The generic understanding about science-as-knowledge is that science is an activity that seeks to *represent* nature or corresponds to how the world really is. But, according to Pickering science is not just about representation. He includes material, social, cultural and temporal dimension in science-as-knowledge to arrive at performativity idiom of science. To explain performative image of science he goes on, "world is filled not … with facts and observations, but with *agency*" (Pickering 1992: 6). In the performative image, science is an instrument – embedded with power, capacity and performance – to capture material agency that emerges beyond the realm of human agency and cannot be reduced to anything within this realm (ibid.).

As Pickering adds temporal dimension in science-as-knowledge to derive its performative aspect, thereby he suggests for real-time understanding of scientific practice[6] (Pickering

[6] Pickering (1992: 3) explains scientific practice as the work of cultural extension and transformation in time. For him, and for the present study, "culture" in broad sense includes skills, social relation, scientific facts and theories, machines and instruments, in sum "made things" of technoscience. Pickering also differentiates between scientific *practice* and scientific *practices*. For example, repeatable activities and sequence of activities on which

1992). The characteristics of material agency are never decisively known in advance. The characteristics temporally emerge during an experiment or development of a machine. Scientists do not know in advance what would be the outcome of an experiment or what shape a machine would take. They continuously have to engage with material agency in real-time in their practice (scientific practice) to draw desired/expected outcome from a material. Problems offered by material agency can be solved or not at the real-time. Such unexpected encounters by scientists in terms: problem manifest the *resistance* of a material. Hence, Scientists have to come in the terms of material agency and have to offer *accommodation* to it, if they seek the desired outcome from an experiment or machine. These accommodations occasionally prove effective to address the resistance and occasionally not. Continuation of such responses from scientists and material agency forms of dialectic of resistance and accommodation that emerges in the context of scientific practice as a transformative work performing culturally and temporally.

It is against this backdrop we make an attempt to understand the dialectic of resistance and accommodation mediated between jatropha and the scientist in the process of development of a biofuel feedstock. The materiality of jatropha manifests in the contours of time, domestication, variety development, response to disease, suitability and sustainability, and environmental and biophysical aspects. For the convenience of analysis, we have segregated these aspects in two categories. The one which embeds the aspects directly emanating from jatropha as an agency, such as temporality in scientific practice, efforts to domesticate jatropha, attempts to develop varieties and disease resistance, and environment and biophysical limitations. Another one includes aspects which are structural in nature, viz. mandates of the research institutes, funding, collaboration and interventions at policy levels.

3.2.1 Temporality and Agency of Jatropha

scientists rely on their day-to-day research work in a laboratory. These day-to-day research practice(s) are generic in nature. These "practices" which are plural in nature does not follow criteria of scientific practice which has cultural and temporal. However, these day-to-day scientific activities should not be confused with the similar term Thomas Kuhn (2012[1962]) uses in his expositions on methods of science in *The Structure of Scientific Revolutions*.

In this section we attempt to trace the temporal aspect of materiality of jatropha that emerges in scientific practice. Here, we bring in the responses of the scientific community engaged in research and development of jatropha in India. In the initial phase of jatropha plantation, which took place after the launch of the NMB in 2003, various stakeholders promoted jatropha on various facets, one among them was its high growth and yield rate. Many of the promotions ignored the unpredictability of the plant which only emerged with the act of doing. According to one of the scientists from CSIR-sponsored Central Salt and Marine Research Institute, Bhavnagar:

> The plant was going very well, so people were very happy with that. But as the time crossed, you started coming up with many problems, different people faced different problems. So as the time passed, people realised that the problems are those about which they never thought initially. Previously it was published with so many hopes: a wonderful plant, so much of yield so etc. etc. When there was a mass cultivation, and foreign people also recognised soon, it could perform and continue in the same way, the way it was projected.

Another scientist from the same institute understands temporal aspects in terms of maturity of the plant:

> Jatropha takes four to five years to get into full bloom state. If they adopt it, break-even is not achievable before eight years. Some government support should be there to encourage farmers. Till now nobody has got subsidy, economy should be taken care.

A majority of the scientists (76 per cent) relate the success of a project with the time allotted by the government or funding agency. For example, one of the respondents from CSIR-sponsored National Botanical Research Institute, Lucknow compares the emphasis given to jatropha vis-à-vis other food crops in the context of research and development:

> Generally, we talk about rice and wheat. how much research, funding, and a lot of resources have gone for rice and wheat. And with jatropha, you [GoI] seek that in three to five years of research you expect from a plant a good thing. You cannot expect this. You need some work to be done, you need some space for that which was not given by the government. And in present scenario the government expects quick product with the research of two to three years. To get a product a lot of research is required. Around fifteen to twenty years are

> required to get a sound product. This is also the reason why CSIR is going down. We are unable to give product to society.

On a similar note, a senior scientist from ICAR-sponsored Natural Resource Management Division, New Delhi, points out the recess in jatropha research owing to policy interventions and financial support:

> We prepare a policy after having a lot of experience for a particular project. in this case of jatropha there was not much time when policy came and there was not much background information available as well. Though jatropha was introduced in the late 1970s and all of sudden again it was reintroduced in 2002-2003. This huge gap leads to under growth of jatropha, and at that time [2003] there was no dedicated funding available for conducting research and development in this area. The projects offered to the scientists were also very short term, to develop a variety for any crop it requires at least ten to twelve years. With such short duration one should not expect desirable results. Therefore, we could not go beyond certain limit.

A scientist from the University of Delhi is dissatisfied with the government's approach towards research and development

> The problem in India is that government expects quick results, within three years of inception of any project they start asking about the outcomes or product. Research requires more time. This is very short period to achieve something in sciences. Our system is very slow, when fund will be released, when will the work start? With the academia and administration all these problems are there. If one has taken a project, it becomes the sole responsibility of the investigator, nobody cares to support afterwards. Funding has been dried especially in science. The problem with us [a casual aptitude towards research] is we are expected to finish everything within three years.

One of the scientists from CSIR- sponsored Central Salt and Marine Chemical Research Institute, Bhavnagar, has similar opinion:

> I was engaged in one major project and one minor project on biofuels. It was intended to improve the quality of jatropha or to work out how it works best. But, I noticed the initiatives suddenly dried out. I do not know what they are planning now, but it was planned very badly, because jatropha is potentially very good plant, that is why I jumped into jatropha research but it has not been given

> sufficient time. But somehow people could not understand this aspect, that a project requires sufficient time.

A scientist from the University of Agricultural Sciences, Bengaluru, observes the complexity in jatropha plantation which arises with seasonal change:

> Like any other plant jatropha requires water and nutrition to produce good yield. It can be grown around the bunds, that is ideal for getting good yields. Because the moisture content remains there in bunds for a longer period even in summers. Jatropha can draw moisture and nutrients if it is grown in bunds. In plane topography, moisture goes down in the month of February to March, trees shed their leaves and there is no nutrition for the plant. And, it is the time when it flowers but due to less moisture and nutrients it cannot produce fruits.

From the above accounts of the scientific community we can infer that a majority of the scientists (76 per cent) perceive time as a factor for research and development in general and especially in the case of jatropha in particular where time allotted by the government and funding agency was quite limited. The promotional claims made in the NMB could not be corroborated owing to unpredictable behaviour from jatropha. Materiality of jatropha affected the expected outcome such as of growth and yield, and also manifested in terms of seasonal change.

3.2.2 Biophysical Agents and Materiality of Jatropha

In this section we continue our discussion on materiality of jatropha in scientific practice. Here we focus on the biophysical aspects that facilitated jatropha to exercise its agency.

One of the scientists from the Council of Forestry Research and Education, Dehradun draws our attention over the necessity of water and fertiliser depending on the soil characteristics, and how a plant mediates with these external elements. She explains:

> Any crop requires soil with fertility and water. These two are very important. Unfortunately, some of the soil may not have fertility, so you have to complement with the fertilisers, there is no alternative. Second concerned is water, you cannot produce water. Particularly when you go for big trees. The root must get some water from somewhere. The proportion of drylands in India is considerable. The agricultural scientists have classified these lands, but

> classification should be based on water and fertility. And, they must identify appropriate plant for such land, and they should plant these plants. I do not think this collective approach is being practiced currently in India.

Similar requirements are unavoidable for jatropha too, as complimented by one of the respondents from the Maharana Pratap University of Agriculture and Technology, Udaipur:

> The only thing is that when jatropha got knock it was presumed that you can it anywhere, it does not need any fertilisers, water…that was not at all. This is plant, like any other normal plant, requires water, fertilizers and proper care. If you want growth and proper yield, even if it is a costly affair.

One of the scientists from from ICAR-sponsored Indian Grassland and Fodder Research Institute, Jhansi, opines that deficiency of water and fertiliser affects the yield of jatropha, but it is not an exclusive condition for survival of the plant:

> This plat was projected as it can be survived in all condition, without any requirement of irrigation, fertilizers, but that is not the case. It will survive but yield will be less. To take the yield you have to apply fertilizers, irrigation… Another problem which results from these deficiencies is the population of male and female flowers. Seeds are bared by female flowers and the ratio of female to male is 1:30, lesser number of female flower results in less yield of jatropha seeds.

Agreement on necessity of water and fertiliser for jatropha's performance also comes from one of the scientists from ICAR-sponsored Central Agroforestry Research Institute, New Delhi though he emphasises only on rain water harvesting for biofuel plantations:

> This plant will only survive but will not perform. It can grow in the semi-arid region, just live but will not flower and fruit at expected level. So, any plant for that matter requires water, nutrients, etc. for the required yield. So that means, we are not advocating people to water and raise these plants. Instead rain water should be only source of watering in such plantation. Jatropha in plantation mode or in close aggregation definitely it draws more nutrition to produce the yield and oil. With less moisture and nutrition, it cannot perform. Therefore, this is not the plant which can grow in dry situation and perform well, it is not a realistic situation. Jatropha per say, for semi-arid region is a wrong crop, because all plants require water transpiration and for this they require water. So, water availability is crucial is for all plant. Usually tree crops are suitable for semi-arid regions because tree has a deep root system, therefore they have the ability to

> extract water from the deep soil, bushes cannot. And the area like Rajasthan where we have problems of sand dunes, there also we can promote deep root system plants.

One of the scientists from CSIR-sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar, perceives the limiting conditions of the nature of land:

> Where there is frost problem jatropha would not grow. In the USA they tried in frost zone and they got failed. In spite of us publishing the paper stating that frost is not the proper place to grow jatropha, they grew it and lost millions. The problem is that people do not listen to researchers' advice and just go on doing whatever they feel for making quick money. This the reason that earned a bad name to jatropha. It is not a problem of jatropha, it is people's problem. People followed the grey literature which states that the plant is amenable to everything and everything. You just throw it, and it will grow.

The scientist goes on to explain the bearing conditions for the plantation with respect to soil management:

> At the time of planting one has to concentrate on two factors: proper soil management and proper selection of plant. What people did, they just got the hold of some seeds from forest and planted them which resulted in no yield at all. Selection of germplasm is the most important criteria, we should be careful about this.

Another scientist from ICAR-sponsored Indian Grassland and Fodder Research Institute, Jhansi, pushes for multispecies approach for varying geographical condition. He exemplifies:

> Now we have sufficient practices and packages for different regions. Say, for the Himalayan region land management system is focusing on fodder and fuel-based tress, because in the hilly areas fodder is the main problem for livestock, because their agriculture is highly dependent on livestock. For this region silvopasture system has been identified. For the Indo-gangatic region fast growing species or industrial species are being focused like poplar and eucalyptus. In arid and semi-arid regions fruit-based systems like *amla*, *mahua*, etc, where farmers can get returns from the starting itself.

In the context of multispecies approach of plantation in general and particularly biofuel feedstocks, the Hassan Biofuel Park and Agricultural College, Hassan, has been practising

the employment of multilocational and multispecies for biofuel feedstocks. One of the respondents from the institute elaborates:

> It is the land terrain, soil condition and the moisture that is available, based on this we have a cafeteria of species. Five to ten different species like pongamia, *neem*, simaroba, jatropha, *mahua*, cabefilum, *amora*, *mesuwa*, rubber. We have variety of species which are suitable to different agro- ecosystem and land. In any given place minimum of five species we can grow which are fairly suitable. For example, if we have a dry land like this, best species that can grow in this condition are pongamia, *neem* simaroba, and *amora*. These four species are doing well in this dry region. Jatropha can also be one but, it is more suitable for elevated buds, not in plain fields. The pants which have been selected, we have already done some research in terms of identifying the best clones with high yield and high oil content. All these species are thoroughly studied by us. Here biotechnology may be a tool which can be used, as of now it is easier to "adopt" [domesticate] these plants because long gestation periods takes more time. We studied across southern India and made some selection and we have best clone of high yield.

From the above perspectives of scientific community on biophysical factors mediating with a plant, especially with jatropha, we infer that the biofuel policies and scientific community ignored these factors while introducing jatropha plantation across the country. Indeed, we observe that in some instances a few of the scientists (16 per cent) cautioned about the plantation in large scale without considering geographical factors. Nonetheless, a single umbrella policy on biofuels was implemented across the country without taking temperature, humidity, soil, land topography, so on and so forth into account.

3.2.3 Domesticating Jatropha

The metaphor of domestication has been the hunch in STS scholarship (Callon 1986; Latour 1987). It indicates taking control of material agency in scientific practice. Scientists as human agents try to control, capture, enrol, or materialze an object of their experiment. In their endeavour to domesticate, performative nature of scientific practice comes to mediate with an object in order to enhance the capacity of human beings. The scientists enrolled in the biofuel network attempt to domesticate jatropha. Jatropha is not native to the Indian subcontinent. A few studies on the origin of jatropha suggest that it has origin in the South American continent (e.g. Heller 1996; Dias et al. 2012). As the plant is not native to the

Indian subcontinent it has less variation and has not optimised to the environmental condition of this region. One of the scientists from CSIR-sponsored Central Salt and Marine Chemical Research Institute, Bhavnagar, opines:

> The main problem with jatropha is that it is not fully domesticated in our country. Though a lot of research has been done for its domestication, but still we do not have many good varieties. We are lacking in quality material for plantation. If the seed from some unknown material — just for the purpose of growing somewhere in the fields — then it leads to difficulty in evaluating the performance of particular plant. We do not know how much yield would occur and how the plant would perform, the reason is the seeds are taken from unknown material. On the other, we have material which has been tested from past years and we are monitoring their performance year after year. If you are planting unknown material i.e. undomesticated, it is waste of resources and it will not produce expected yield. If the objective is to cover the unproductive area with green unknown material can be planted, but before taking the plantation at commercial level material's genotype should be known and to get considerable economic returns land must be fertile to some extent, and some expenditures should be made on fertilisers to improve the soil.

One of the scientists from ICAR-sponsored Directorate of Oilseed Research, Hyderabad, relates jatropha improvement programme with domestication process:

> There were no crop improvement programmes for jatropha. Whatever we see in the wild, we went on collecting it, assembling it, cultivating it. Any crop requires thirty five to forty years of domestication. People do work on it. Like, finding the genetic diversity, the potential, and then you find a candidate plus tree (CPT) which is high yielding, and at last you bring seeds from these plants. But jatropha is a cross-pollinated crop, and you might have some figure of mother plant. But you do not expect the same progeny what you have observed in CPT. And, even in the wild when you have seen so many crops, then it may or may not exhibit the potential, this is another failure. Good planting material we never had, no breeding, nothing. We just brought the material from the wild without it has been domesticated, we tried to promote it.

One of the scientists from ICAR-sponsored Central Research Institute for Dryland Agriculture, Hyderabad, elaborates the process conducted for domestication of jatropha:

> We identified top ten accessions of jatropha across the country with high oil content above thirty six per cent. Five accessions possessed elite character of high oil content ranging from thirty six to forty two per cent among 600 jatropha

> tree surveyed across the country. Along with jatropha the top five biofuel species, three more new species, *mesua, amoora*, and *surahone*, have oil content above forty five percent suitable for Western Ghats and the coastal areas. The trees survive well in their native habitats. Techniques developed for production of biodiesel from various other feedstocks such as rubber seed oil, waste vegetable oil, cotton seed oil, waste coconut oil and dairy scum. A variety of other raw materials have been identified for this purpose. However, availability of the identified feedstock is key to success and sustenance of biodiesel production as an industry. Improved growth and quality of the seedlings at nursery stage - the seedlings at nursery stage were isolated with consortia of vesicular arbuscular mycorrhizae resistance to disease and better establishment of seedlings at the planting sites.

A scientist from ICAR-sponsored National Bureau of Plant Genetics, Hyderabad defines domestication is a "*systematic and sustained research with identification of suitable wild species, use of genetic resources and simultaneously the availability of quality mass production systems*". However, a scientist from the University of Delhi has different understating about domestication of a plant which does not align with the perceptions of other scientists quoted above:

> With the plants case is different. All types of variation exist in nature and that variation is exploited to develop a crop. It is different from domestication. Domestication is all about selection. Domestication is for specific purposes like yield, you try to domesticate or select those traits which are useful for the main purpose of yield. For example, earlier varieties of tomato used to be small earlier. Similarly, for jatropha we pick up those plant which have good seed concentration, oil content and potential to convert that oil into fuel. Introduction does not necessary mean import of the varieties. But in recent time introduction refers when brought something from outside to India. Like Chattrapati/Sonara which was brought here in India during the Green Revolution from Mexico that was dwarf variety which had different potential. The point with jatropha is that the overall variation is very limited.

One of the scientists from CSIR-sponsored Indian Institute of Chemical Technology, Hyderabad is critical about the approach on domestication of jatropha which led to failure, according to him:

> Non-edible oils are very less known in our country. Obviously, there are some oils which are used only for the industrial purposes, but organised farming is not there for non-edible oils. A few African countries were planting jatropha, and

> India it is abundant in some forest patches. So, some agricultural scientists projected jatropha for the biodiesel. Many seeds of different varieties were brought to India and those have not given a single fruit after the 10 years of plantation. We should have not chosen the jatropha in first place, and even if went with it, we should had chosen proper variety after proper scientific research. We did not do this, now the whole programme we are considering as a failure. It is a failure, not because we do not have technology, but we chose the wrong variety or wrong seed.

From the above discussion on approaches to domesticate jatropha domesticating, we identify that various institutes are working to develop hybrid that can be grown in different soil conditions. The primary quest for domestication is to achieve the best quality germplasm, then go for its multilocation trials. A majority of the scientists (72 per cent) opine that hybrids need to be developed through multi location trials.

3.2.4 Mediation in the Development of Varieties

In the previous section we have discussed how the scientists define domestication, process of domestication and differing or conflicting understanding of domestication of jatropha. Here we attempt to locate the materiality of jatropha that appears in the process of variety development. In the process of domesticating jatropha variety development stands out as one of the taming instruments to capture material agency of jatropha. One of the scientists from Tamil Nadu Agricultural University, Coimbatore, explains the importance of having variation in a species:

> When a plant is introduced, you end up getting less variation, and when from it you want to develop a fuel crop these must be basic variation. Basic variation like in human beings: different textures, bodily features, this variation within humans are the key to their evolution and development. We keep on meddling in humans' development through medical interventions, social interaction etc. there are so many components which create a situation where weak linkages can be intervened.

According to a scientist from ICAR-sponsored Directorate of Oilseed Research, Hyderabad:

> We do not have any established variety which can perform all sorts of soil. As for other crops like wheat and rice we have many varieties for various sorts of areas, soil and climate. Some people have developed the varieties, but their varieties are restricted to specific areas only. Suppose we are working here, it is

> a semi-arid region. The variety we have developed here will perform well in this area only, we call them location specific varieties.

One of the scientists from CSIR-sponsored National Botanical Research Institute, Lucknow, elaborates the on process of germplasm for the variety development:

> I had one project three years ago sponsored by DBT for improvement of jatropha for high productivity and increasing the oil content using advanced molecular technology like molecular marker. We collected various varieties across India and from outside as well and evaluated their genetic composition. Jatropha is wild growing plant, we collect it from different wild areas. One accession is selected from one region and another from around thirty km distance away. We assume that within this range we would be able to find the plant of different accessions with some genetic variations. For this, we targeted twenty five states and collected around 150 accessions. There is also a possibility of duplication of the accessions even you are collecting from such diverse regions. Our work was to differentiate each variation and evaluate the potential of that particular accession for one region or multiple regions.

Another scientist from ICAR-sponsored Directorate of Oilseed Research, Hyderabad discusses on developing non-toxic varieties and compares with other countries:

> We have both toxic and edible type also. In Mexico and Brazil, non-toxic variety has taken the impetus. But we are not taking non-toxic varieties. If we have the thing, why we not doing. There should be a systematic way to do, what I think. Take a few institutes which are working towards biofuel purposes like IICT, IIPM, should work together and come out with a promising product. One of the advantages of jatropha is that it can be used as straight vegetable oil. In other oil you have to do another step of processing. This is a quality oil, it can be used for direct blending. Or it can be used as straight vegetable oil in engines. If it is castor, it is quite viscous, so again you have to process, theta becomes expensive.

Not having proper variety at proper time that led to not so optimistic outcome from the biofuel mission: not the land factor. According to a scientist from the G.B Pant University of Agriculture and Technology, Pantnagar:

> Jatropha failed not because of land factor, but the cost occurring to produce the oil. At that time when it was pushed by the Planning Commission of India, we did not have yielding varieties of the plant, and what accessions were available, the yield from these was also variable. So, we could not provide the qualitative

> seeds required for the projected biofuel consumption. Earlier good planting materials were not available, now after the research we have developed good planting materials. But now the government is pushing for solar energy. If you browse the ministry website everywhere is solar energy. Many people, such as industry, scientists, policy-makers, say that jatropha is a failure. Jatropha itself was not a failure, every plant needs some care. It was planted and left without care,

On the employment of genetic engineering for disease control, a respondent from the Indian Institute of Technology Guwahati reflects:

> In genetic engineering front, most important problem we are facing is disease problem like viral infection and fungal problem. Their attack can kill a five to six years old mature plant within a span of fifteen days. Here, biotechnology is required to develop some disease resistant germplasm. We are also trying to develop genetic markers for conventional breeding and molecular plant breeding. Singapore is developing a GM variety. We only can hope disease resistant factor would be taken care in this.

The development of a variety is also coupled with the aspect of harvest which would be convenient for the farmers. One of the scientists from the Jawaharlal Nehru Agricultural University, Jabalpur, has expertise in developing dwarf varieties with synchronous maturity. He elaborates:

> We are working on dwarf varieties, that means we are limiting the height of the plant to four to five feet, so that it will be easier to farmers to pluck its fruits. Jabalpur Agricultural University has also developed a hybrid in gynocious (problem of less female flowers) lines. Moreover, we are working on to achieve synchronous maturity for the plantation: in a branch, different flower and fruit bunch have different maturity period, first flower's fruit will ripe first and so on. In synchronous maturity all the fruits ripe at the same time. It makes the harvesting easier. Otherwise some bunch would be green here, yellow there. A lot of labor is required in this situation.

A few scientists (20 per cent) have had apprehensions about large-scale jatropha plantation. They are suspicious about a premature push to cultivate jatropha, inadequate understanding of the basic agronomics could lead to unproductive agriculture. It can be traced in the suggestion of one of the scientists from CSIR-CSMCRI, Bhavnagar:

> In genetic engineering front, most important problem we are facing is disease problem like viral infection and fungal problem. Their attack can kill a five to six year old mature plant within a span of fifteen days. Here, biotechnology is required to develop some disease resistant germplasm. We are also trying to develop genetic markers for conventional breeding and molecular plant breeding.

Apprehensions over the use of genetic engineering come from one of the respondents from the University of Delhi:

> For jatropha we pick up those plant which have good seed concentration, oil content and potential to convert that oil into fuel. With these selected plants we develop a variety through breeding or biotechnology. We Indians do not prefer biotechnology interventions though there is no problem, so breeding is safer option. First initiatives from the government should be study the variation. Variety should be developed in India and if required should be imported from place like Guatemala where large variation of Jatropha is available.

One of the scientists from CSIR-sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar, draws attention over promotion aspects vis-à-vis difficulty they encounter in the process of developing disease resistance varieties of jatropha:

> Basic problem for any plant is disease. Jatropha is also susceptible to different kind of disease: fungal, collard, affected by virus infection, insects and pests are also friendly with this plant. Previously it was assumed that the plant is resistant to disease but now in different places people observed diseases in the plant. What we want plant should be resistant to some of diseases. Attack of virus is also a big problem, it retards the growth of plant and the plant dies soon. But, fungal, bacterial and insects can be controlled by some sort of pesticides and insecticides and some other management, but virus is such a problem which cannot be managed. Hence if we have some viral resistant plant that would be good. But scientifically it is very difficult because virus generally keep on changing their structure. That is why it is very difficult to eliminate virus, but in science nothing is impossible what we can expect.

Another scientist from the same institute has similar opinion

> What we saw was the attack of viruses. And it was not one/ a specific virus, there were group of viruses and those were damaging different parts of the plant and restricting the growth. Other than these we observed, in the initial years of the plantation we were not getting the proper yield, fruiting was fine and seeds were also seemed healthy but oil content was very less.

According to one of the scientists from the Indira Gandhi Agricultural University, Raipur, there is a contradiction in projections and practices in biofuel promotion. He suggests:

> People thought jatropha does not require water, it does not attract pests. May be some people must have seen some forest and good varieties of jatropha. But in reality, when you are bringing it to other land it was not proven, and it went seriously wrong. At that time they want to apply this practice of plantation throughout the country in a very big way without testing the land, plant, and seedling. Government, industry, agricultural scientists should look at throughout the world. For example, we know what types of lands are there in India. Can we really link with any other who has similar conditions? What are others practicing in this area, if they are doing well, we can learn from them. There is nothing wrong in copying them.

One of the scientists from CSIR-sponsored National Botanical Research Institute, Lucknow, acknowledges the unpredictability of jatropha which was ignored by a few scientists and promoters:

> Infections from viruses are more prominent and damaging because we have some chemical solutions for bacterial and fungal infections, but presently we are not able to control the attacks from viruses. Since jatropha is a wild species and nobody was aware of jatropha's immunity against viruses. When it came for the cultivation and when we started propagating the plants in fields then only we realized that the plant is very susceptible to virus and virus has a catastrophic impact on the plant. As jatropha is a wild species and wild crops have poor genetic variability. The implications/limitations of this is on crop improvement methods/programme. If someone want to work on Jatropha in future they should focus on how the genetic variability of the plat can be increased and further the resistance for virus attack.

A scientist from CSIR-sponsored Central Research Institute for Dryland Agriculture, Hyderabad, observes catalyst of a plant disease coming from soil which in turn affects the plantation growth:

> In some places the plantation is struggling with borer in the soil not in the leaves. They bore the tree roots and make it hollow even after the tree has reached in mature stage. The reason might be soil itself, soil in those regions is red and sandy which provides the favourable condition for the growth of borers. Agricultural practices should also be considered, it is not the situation that you just plant the tress and leave them without proper care, and plants require proper

> care like any other plat. There all are the problems we faced at practical level in the fields.

Another scientist from the same institute emphasises on the basis requirement of a plant even if varieties have been developed:

> Supposing that you are developing high yielding variety seed for good yodel and good oil content, but again this varieties will require water, fertiliser, and other proper care. Ion the part of GMO, I have not heard anything related to GM and work on jatropha, where the limitations of high yielding varieties can be addressed. The approach of Indian government is to restrict the import of biofuels, specially from the countries like Malaysia, China, so that industries at the home can create infrastructure to produce biofuels at home. But in this way the cost we are paying for biodiesel is more.

Our discussion on this section attempted to capture the manifestation of material agency of jatropha when it came into the scope and ambit of scientific practice. To summarise, a majority of scientists (76 per cent) are of the opinion that jatropha can survive without water and nutrients, but cannot bear fruit or would bear in lesser quantity than expected or projected in the biofuel policies. The plant is also susceptible to various diseases, viz. fungal, pests, insects, borer, collard, virus infection, etc. For a majority of the scientists (82 per cent), the main *problem* with the jatropha is that it is not fully domesticated in India. According to them a lot of research has been done for its domestication, but still they do not have appropriate varieties of the plant, thus they lack in quality material for the plantation. However, we argue that the problems faced by the scientists are the manifestations of the agency of jatropha that mediates through resistance with the scientific practice. The development of variety to address the factors of biophysical, domestication and to make the plant disease resistance employed as accommodation from the scientific community.

3.3 Institutional Mandates and collaboration in the Biofuel Network in India

In the previous section we have discussed the material agency of jatropha that manifests in contours of time, domestication, variety development, response to disease, and biophysical aspects. In this section we attempt to capture the interplay of jatropha's agency with the 'structure'. By 'structure' we imply the mandates of research institutions, funding and collaboration, intervention at policy level pertaining to biofuel network in India. Here we

attempt to figure out how those dimensions of the dialectic of resistance and accommodation emerge in the structures and operate in the dynamics of socioeconomic, political and cultural sphere.

3.3.1 Shifting Mandates and Policies: Dilemma of the Scientific Community

The mandates and norms of an institution are generally followed by member to pursue research activities within the frame of set policies. On the one hand, the mandates provide a conducive environment in the pursuit of research. And, on the other, it poses constraints. Often constraints appear in the form of availability of funding, time restrictions, or shifting political agendas, especially in the case of public research institutions as these are dependent on the government funding. One of the scientists from CSIR-sponsored National Botanical Research Institute, Lucknow, expresses:

> You keep on changing our (CSIR) policy in daily basis, *aaj ye kaam kar do kal wo kam kar do*, you started with some objective, in between you shifted to another objective and concluded into the Clean Ganga Project. This is not the way of doing research. This is same what happed to this [biodiesel mission] and this is what going on with other projects as well.

The scientist goes on to state that the limitations arise owing to funding from the government:

> They say, they resist, but at last they are also dependent on government for the money. If you will provide money then only we would be able to do work, the government says only if you will do this project then only we give the money. The scientist will keep on doing the same work which is asked to do.

On the question of policy and CSIR mandates pertinent to jatropha research, one of the respondents from CSIR-sponsored Indian Institute of Chemical Technology, Hyderabad, explains:

> I am not very sure about policy, but we started working for jatropha in 2005 and very much engaged in it till 2013-14. We were mainly engaged in exploring the various environmental factors which could affect the plant, collection of germplasm, conducting field trial, and accessing the suitability of the plant for various regions especially for draught prone areas. The projects related to jatropha were short lived as compared to other projects we were engaged with.

> We can say its total failure main reason was economic viability, nothing to do with oil part or content. In research point of view, one cannot expect results in short duration, we should have patient for substantial outcomes. Now the mandate is shifted to biofuels from algal, but personally I feel algal is not viable for India.

Another scientist from CSIR-sponsored National Botanical Research Institute, Lucknow, states that research on jatropha is not one of the mandates of their institute:

> Around 2012 we had some projects and we partnered with other stakeholders from Rajasthan, Tamil Nadu, the North-East India, etc., but here (NBRI) we have shifted our inclination away from jatropha after the completions of these projects, because many of our scientists were arguing that it not our main objective (as per CSIR mandates).

One of the scientists from CSIR-sponsored Indian Institute of Chemical Technology, Hyderabad, points out the shifting approaches on the biofuel programmes with changing political regime in India:

> Without knowing anything they behaved like as an expert. Our decision-makers and policymakers went blindly with jatropha. If I am correct, BJP was in the final year of the government, and Mr. Tiwari was interested in biofuels. Within the span of six months, without doing much groundwork they came out with biofuel policy. Then another government came, somewhat they did not give that support. Irrespective of the government, my opinion is that agricultural scientists should have done a proper groundwork before drafting the policy.

Similarly, one of the scientists from CSIR-sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar, sees diversion of funding to other projects prioritised by the government:

> I was having Rs.1.8 crore project for jatropha and that is over. Presently I do not have any grant for jatropha. New funds are in the process. But, now the scenario has changed. New government is focussing in different issues like, Make in India and Swachh Bharat Abhiyan.

Another scientist from the same institute has a perception that is in stark contrast to the views we have quoted above on the mandates of the institutes on jatropha research. She contends:

> As a researcher we are taking the interest and doing the work, but any funding agency supports only for four to five years. Crop like jatropha, where you expect production only after five years, or for pongamia and simaroba after eight years. With such limited duration funding you start it and close it. In this situation what will happen: investment will not be attracted in larger domain, only research institute like us will continue in such scenario. And, particular group of crops have never been a mandate of CSIR and ICAR, then who is going to take it up, that was another issue. There are specific research institute for specific crop like rice, wheat, rapeseed, etc. but there is no specific institute for jatropha or biofuel as whole. Everything is scattered like funding from NOVOD, DBT, DST, ICAR. But if you see countries like Thailand, entire focus has given only in one centre like centre of excellence for jatropha/biofuels; and they have not taken any other biofuel crop other than jatropha. There around 100 scientists, chemist, breeders, and so on work together in one institute. They have specific target 2.5 tonnes per hectare. Their plantation is economic, they go for dense planting, and they got success. But in India we do not have this specific approach. Though there was lot of funding from various institutes. Now you ask DBT, ICAR, NBPGR they all claims that they have high quality promising materials, it's all in the reports, but you never see these materials. That is the irony of the whole situation. There was never systematic breeding approach in India.

However, one of the scientists from the Institute of Environment and Sustainable Development, Banaras Hindu University, Varanasi, is quite optimistic about the future of biofuels in India and insists on the focussed mandate for biofuels:

> Consistence political will is required to continue such programmes. What we saw shifting programmes, like solar energy is now in trend. But we should not forget, all vehicles are running on fossil fuels. We have not made transition into solar energy operated vehicles. Therefore, biofuels are still quite relevant in coming future.

3.3.2 Scenario of Collaboration and Funding

In the context of the mandates and protocols of specific institutional collaboration is an important aspect in the pursuit of research. The scientists engaged in jatropha research collaborate with scientists drawn from a variety of institutional settings such as national research institutes and international research institutes, mission-oriented research institutes, both public and private. In this section we attempt to understand the present scenario of collaboration among various institutions and organisations. Our purpose is to mark out the nature of the collaboration, the factors that affect the collaboration, and in turn the mediation

of jatropha's materiality in these interplays. A majority of the respondents (77 per cent) in the present study cite availability of funding as one of the determining factors in the formation or continuation of collaboration in jatropha research. According to one of the scientists from ICAR-sponsored Central Research Institute for Dryland Agriculture, Hyderabad:

> I was consultant to Nanadan biofuels. But the sufficient support from the government was not there, so I stopped my activities there in midway. There I was involved in molecular characterisation and improvement of the plant. We have also closed our Berhampur, Odisha, plantation project due to insufficient funds. Now fund is really a problem for jatropha research. Earlier, funds were available from the US Department of Energy, Daimler-Chrysler, the Government of India and the United Nations.

One of the respondents from CSIR-sponsored Central Salt and Marine Chemical Resarch Institute, Bhavnagar, is not comfortable on the issue of grants:

> Pests resistance, low water requirement, high yield, for all these purposes the government was giving money to some institutes. But today what kind of funding is available I cannot say. These days government is reducing the fund, and asking that the research organisations should be self-sufficient. I do not want to go on these details, we got some grants, but, DBT, DST, ICAR these have given some grants, but as far as biodiesel is concerned we have not achieved any significant results. The approach was not focussed. Everything was scattered. They (funding agencies) distributed funds in each and every institutes claiming that they work on jatropha. NOVOD board, DBT, DST, etc. diverts funds to these institutes.

However, another scientist from ICAR-sponsored Central Research Institute for Dryland Agriculture, Hyderabad, has apprehension on the existence of collaborative network in biofuel research in India:

> When you think of a crop for biodiesel purpose there was no collaboration and cohesion between different agencies. There was no networking. Ultimately biodiesel is for the companies like IOC, HPCL, etc. They should have been involved in networking. And the plantation improvement institutes, then what is the need of the industries? How much economic yield should be there to make it commercially viable. So, we have neither planting material nor the linkages

between the institutes, the industries and the farmers. For the farmers, unless ant crop is not remunerative, they will not take it.

One of the scientists from CSIR-sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar, comments on the specific role of public and private research institutions on the variety development for jatropha:

> As far as private companies are concerned they are developing only hybrids. Every year they are developing and selling. They have resources and facilities. They can invest every year and develop a hybrid and sell it to farmers. In case of public research institutions, they cannot invest in hybrids therefore they are focusing on development of varieties. The private research institutions are making changes at molecular level, tested with DNA finger printing. With this at seeding stage testing of characteristics can be performed, it reduces the time, otherwise we have to wait for four to five years.

Contrary to the above views of the scientists present not so optimistic situation on the collaborative scenarios in jatropha research. However, a few scientists (20 per cent) seek for the collaboration in research and development of jatropha. One of the scientists from ICAR-sponsored Directorate of Oilseed Research, Hyderabad, emphasises on the need of collaboration:

> Certainly, I feel, because wide varieties we have, and we grow in India, we can certainly be at forefront. Institutional and government support should be there, linking all the stakeholders. Some works in isolation, what they do others, do not know. We can also involve corporates, they can afford…., at least they can develop some prototype, adopt a few villages, then they can replicate that in other places.

One of the respondents from CSIR-sponsored Indian Institute of Chemical Technology, Hyderabad, invokes the role of industry in research and development to achieve innovation. He relates risk and economics of innovation:

> What the industry wants? Feedstock! And has to be provided by agricultural scientists. Unless you have a feedstock it's not viable. Somebody is producing one tonne per hectare, it is viable, someone is producing 0.5 tonnes per hectare, is it viable? Basically, if the feedstock is available to the industry with appropriate price then industry will be happy, and will be attracted to start or

continue with the production. So first priority for the industry is the feedstock and if the feedstock is available at viable price then the second should be the technology. Say, if feedstock is costing Rs.50 per unit and technology Rs.6 per unit of production, and if they can sell it only for Rs.36 per unit then it is not viable business. Now let us assume that feedstock is Rs.25 per unit and technology with same rate for today, then 31 rupees is reasonable. Unfortunately, in India even though industries are networking with all India institutes and farmers but I feel it is still long way to go. Industry has to spend some percentage of money for research. Usually when they come to us they really want to develop some project in six months or one year. They want a positive commitment from us that within six months we should transfer the technology. Industry should be prepared to take chance or risk. Unfortunately, very few Indian industry take risk. If you do not take risk you cannot expect a great innovation. If you are aspiring for some innovation, you need to throw some money, an innovation will not come just like that, you need to work. When you really doing work, we think that you would achieve something but sometime what happens you may not achieve something. Then it will be very difficult for scientists to come with innovation. That is the reason why industry or R&D institute shake hand. Particularly when it involves feedstock oriented some agricultural product. Naturally farmers, industry, R&D institutes, along with the government they should have some sort of agreement. Here I also expect industry should invest some percentage of money continuously. When industry cannot throw money, government has to really provide some grant to R&D institutes and after coming out with innovative product. Basically, networking is very important here. In general, in India industries are slowly gearing up for networking with R&D, but still long way to go.

According to one of the officials from the Chhattisgarh Biofuel Development Authority, Raipur, collaboration in biofuel research can be achieved by policy interventions from the government:

Around 1,50,000 hectares of land been planted initially. These plantations started producing large amount of seeds. Like other plants, if you water them, provide fertilisers in regular intervals they will flourish. But after initial plantation government did not take care about scheme so the plantation can be maintained. Though the government suggested to form a joint venture with HPCL and IOCL, so the plantation can be maintained. We collaborated with them and handed over the planted area of 20,000 hectares each for further maintenance. After installing the plant, we proposed same to a few private companies. And it was; one of the reasons of collaboration with IOCL and HPCL. But the government did not come with clear policy. With all the characteristics of environmental friendly – no sulphur, no lead, low viscosity, optimal pour point, safe flash point, and no pollution – the government of India did not insist on blending. Indeed, they created obstacles to us. We were producing biodiesel, and they did not allow us

> to sell the same in market. They said, you cannot sell it directly in the market. Then, to whom we should give, the government said, we will buy, give it us at the rate of Rs.26 per litre. Now see, you are selling diesel at a price of Rs.55 per litre, and asking us to sell our biodiesel at Rs.26 per litre. Why should give it at this rate? Their support price was never encouraging. They did not provide protective price. It was a kind of sabotaging, so that we cannot work. Even we were using biodiesel in our vehicles; we got notice from the ministry of petroleum. You can consume it, but you cannot produce it. Even our chief minister was started using biodiesel for his vehicle for continuous five years. Just to prove that if you are producing quality biodiesel your vehicle can run without any modification. IOCL and HPCL did not take much interest and have closed the sites. They did not appoint any expert of biofuel there. They spend the fund in establishing the sites but not in research and processing projects.

However, a scientist from ICAR-sponsored Directorate of Oilseed Research, Hyderabad, does agree on the need of state support on finance, value chain, but not on jatropha as a sole crop:

> The major issue is the support from the government. Because this is a new crop, plantation is another issue. If we have the quality material, the government has to support. Another is the buyback arrangement for the farmers. Now the government is advocating that you have to go for the soil health card. Now majority of the farmers have soil heath cards. And there is so much government's barren land. First introduce the crop in right perspective, then see what is the potential of the crop, whether it can do or not. Better they should adopt a more focussed approach, and not as a sole crop.

On historicising the need of collaboration, not only among research institute but including all the stakeholders, a senior scientist from CSIR-sponsored Indian Institute of Chemical Technology, Hyderabad, exemplifies:

> When you go to our food grains, thanks to C.S. Subramaniam and M.S. Swaminathan, these two people from political angle, from scientific angle, both of them worked together, and today we are self-sufficient in food grains. In similar way government of India, like in Rajiv Gandhi's time in 1980s, they started technology mission, oil seeds and pulses mission. They really reasonably well. But we have forgotten those initiatives. Even we are spending lacks of crores of rupees on import we are not in safe situation. So, there must be a technology mission consisting of farmers, agricultural scientists, and technology-oriented people, and industry. They must really sit together and they need to look at globally. If somebody is really planting something and getting a good yield, other should not hesitate to take it for appropriate land.

One of the respondents from the University of Petroleum and Energy Studies, Dehradun, seeks for policy intervention to set up a market for biofuels vis-à-vis petroleum market in India. She mentions:

> Funding in this area is right now not dependent on demand side, because the market for the biofuels in India has not developed yet. For market to be established, demand and supply both are required. One will invest in biofuel production when they see some consistency in demand. Recently the Ministry of Petroleum [and Natural Gas] has floated an intend to buy biofuels from the market, and it is worth of crores of rupees. So, such kind of initiatives are required from the government to push the biofuel demand, and ultimately it will stable a biofuel market. Some kind of production system should come out which can reduce the production cost of biofuels.

In 2018, the Ministry Petroleum and Natural Gas appointed a task force to address the issues raised by various stakeholders to strengthen the biofuel market in India. The task force is also responsible to identify other suitable sources as feedstock for biofuel production such as used cooking oil, palm seed, animal fats, etc. in case demand is not fulfilled by jatropha. However, use of these supplementary feedstocks like used cooking oil and animal fats digresses from the motives stated in the National Mission of Biodiesel, 2003. Further, the cabinet committee[7] of the Government of India took decision on selling of biofuels to other commercial sector associated with petroleum products. Earlier the sale was restricted to oil marketing and production companies.

One of the scientists from CSIR-sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar, mentions the previous international collaboration on jatropha plantation:

> Austria Biofuel Institute found that jatropha methyl ester is better in comparison with coconut, used cooking oil, palm, mustard and rapeseed biodiesel. Consistency of jatropha oil was far better than the others. Biodiesel was discovered when there was a project with Daimler-Chrysler with CSIR funding.

[7] https://www.thehindubusinessline.com/economy/policy/cabinet-approves /article23903816.ece, accessed on April 11, 2019.

> Jatropha plantation was there before the project but not for biodiesel. In 1990s, the plantation project was funded with the support of UNDP and DBT

He goes on to explain the current scenario on biofuel research:

> About ten years back research and development in jatropha was at peak, but if you look at the last five years it has gone down drastically. With the same acceleration how it had reached at its peak. Is it because of the government policies or research and development issues? What I personally feel that government has lost interest in biodiesel in general and from jatropha in particular. In spite of lack of interest from government, we were able to extract thirty to forty per cent of oil per unit of the quantity. Economic viability may be one of the reasons, plus a few misconceptions about Jatropha like it can be grown in draught prone area, but it requires quite bit of water.

Current scenario on biofuel research and collaboration projects not-so-optimistic picture in the country, according to a few of the scientists. However, a few of them ((14 per cent) are optimistic about nascent small-scale industries' interest in biofuel market. One of the scientists from the University of Agricultural Sciences, Bengaluru, describes:

> Right now, major industries are not coming forward. They are not interested in small numbers, they are looking for huge numbers. But small industries are coming forward, some of them have collaborated with us. They have been helpful in establishing the village level oil-processing centres. Also involved in value addition through by-products. For example, we have some regular small industries which can crush the seeds and produce oil and oil cakes. And through some of our programmes we are promoting small machineries which can be operated at villages under single phase power supply. But, we have not got any support for research from any industries so far. For commercial application, we are able to supply feedstocks to some small ventures like taxi operators and truck operators who are willing to use biofuels for their vehicles.

Similarly, one of the respondents from the Hassan Biofuel Park and Agriculture College, Hassan, points out the importance of collaboration at micro level, and role of administrative and finance institutions on promoting biofuel plantation. He elaborates:

> The agroforestry department of our state (Karnataka) has recognised the activities of biomass park and supported for extension of the model to other parts of the country and also worldwide. The centre is supporting for development of

> biofuel species consortia with improved yield. The centre is also supporting for development of rural energy and rural employment generation. Fifteen oil expellers distributed to farmers associations. Twenty eight villages are selected to know the effect of six different oil cakes on yield and other characters of ten different crops in farmer's land. Experiment at farmers' houses on use of oil cake in thirteen biogas units in seven villages for biogas production. The National Bank for Agriculture and Rural Development is supporting (NABARD) the technology development by installing five oil extraction machines to demonstrate value audition process with farmers groups. The effort is to encourage the farmers to establish village level enterprises for which NABARD assisted long term loans are being made available.

One of the scientists from ICAR-sponsored Directorate of Oilseed Research, Hyderabad, talks about academia-industry partnership and shifting motives and outcome from jatropha plantation:

> Several biofuel firms also came for research in this area, because the word biofuel catches their attention. The government was planning to lot of subsidies in this. Some companies have also developed the mechanism to process the biomass of jatropha. For a plant source to sink ratio matters a lot. If you look at sesame plant, the number of leaves is very few, but the productivity is very high, that means the yield versus biomass ration is high. In case of jatropha, fruit bearing is less with as compare to the size of the plant, that means biomass is high. Now people are characterising the plant with low biomass and high yield. On the other people have started converting this biomass into biofuel.

Another collaborative network that emphasises on linking biofuel mission with rural energy requirements and industrial needs, especially treatment of land degraded due to industrial waste. One of the scientists from the Defence Research and Development Organisation' research centre Defence Institute of Bio-energy Research (DIBER), Haldwani, states:

> DIBER has carried out pioneering work in development and establishment of jatropha as an agro-economic model for rural areas. In addition to identification of superior high oil yielding germ plasm, the institute has also contributed in development of micropropagation protocol, age technologies for varied agro-climatic zones, standardisation of trans-esterification process, development of value added by products viz., glycerol, biofertilizer, fuel briquettes, soap, producer gas, biogas, nanocomposite fabricating materials and formulation of certified emission reductions. At DIBER, we have identified high yielding planting material, namely, DARL-1 with 34.4 per cent oil content and DARL-2

with 36.5 per cent oil content as promising genotypes, which have been deposited in NBPGR, which have been allotted IC numbers and have also been notified by DBT. Agro-technology for planting in degraded lands successfully established. About 400 hectares land has been brought under Jatropha coverage at Raiwala, Mhow, Ahmednagar and Secunderabad. In these sites we carried out intercropping experiment with leguminous crops to enhance soil genesis and fertility. We are also providing consultancy to CSMCRI Bhavnagar and NTPC Vindhyanchal.

3.3.3 The Problematic of Price Mechanism

A majority of the scientists (80 per cent) in the present study opine that the current price mechanism of biofuel marketing and selling have disadvantage over existing petroleum market in India. For example, one of the scientists from the University of Agriculture Sciences, Bengaluru, compares the pricing mechanism between petroleum products and biofuels:

> For blending, technologically there is no problem. Globally people are using the blended fuel. Yes, commercial factor is there, if the cost of biodiesel is higher than the diesel, it is a point of concern. Government is taking too much taxes in petroleum products, production cost of one litre petrol is around 20 rupees. If government can divert some part of this revenue for subsidy, then biodiesel is commercially feasible, otherwise not. Other important point which I stress on pricing. The price of biofuels should not be compared with petrol or diesel. Petroleum products are economy driven, political things across the globe. Different price mechanism is there for peto-diesel. If you compare, definitely they are not comparable.

All respondents from the North-Eastern Regional Centre of the Energy and Resource Institute, Guwahati, identify over optimism in biofuel price as one of the drawbacks of the National Mission on Biodiesel:

> It is because of the NMB, grants were disbursed to various research centres all over India. Many people got the project and multi-location trials were done. The problem was with support price, which is fixed at rate of Rs.30 per litre. But given the research effort and the cost of the seeds is calculated to Rs.50 to 60 per litre. That is the main drawback of the NMB policy. If you want to encourage, set some realistic goals.

The scientist from ICAR-sponsored Central Institute of Agricultural Engineering, Bhopal, suggests for multi species approach for biofuels backed by financial support. By citing

example of other countries' approach for biofuels, he emphasises on addressing the specific feedstock demand of various stakeholders:

> As we have seen in the case of Mexico and China fencing or other purpose are also important, but here in India we are not aiming those things. Now after the decades of research here we people have identified the varieties which can be grown as a barrier crop, or high yielding crops, spreading and non-spreading crop, you name is they have it. So, if you have such materials, it depends on stakeholders what they need. Now the funding has come to stand still virtually and nobody wish to do research in this. The hype created for jatropha has now come at stand-still. People wand quick result, and biofuel crops only yield after five, six or eight years of range. For plantation crops we should go for long term goals, short term approach never works in such plantation.

On the same line, one of the respondents from the University of Hyderabad, extends his support for biofuels for India in the context of the global oil politics:

> We are just watching the growth from last ten to twelve years without any economic returns. There no alternate fuel in India, you should focus on international oil politics, the prices of crude oil. Here most of the discussion is on oil prices not on oil quantity. On prediction is that by the year 2100 all the fossil fuel will be exhausted. Edible oil cannot be used, non-edible oil, micro algae…these are some alternatives. Real stakeholder should come out, that they are going to invest in the project and government should come out with some support in this sector.

However, a senior scientist from CSIR-sponsored from Indian Institute of Chemical Technology, Hyderabad, criticises the approach taken in the drafting of the biofuel policy and price mechanism, and hasty nature of the state government in implementing them. He elaborates:

> In 2002 when Atal Bihari Vajpayee took the initiative and biofuel policy came, CSIR was also part to contribute in process development. I was also part of the initiative and contributing for the Tiwari report. At that time, I was really cautioning the people that we can produce biodiesel in Rs.20 per litre, I said this is all nonsense. I said we do not have any agronomic system right now. Nobody listened to me, I was very junior those days. So finally, within three-four years everybody realised that jatropha is not an appropriate crop for the purpose. So, whenever you want to proceed with this kind of policy, the government should not dump something of farmers, on researches, basically you need to do proper

> exercise before formulating any policy, because farmers are in distress, the government is not encouraging the agriculture, such policy would only worsen the situation. How people will suffer tomorrow, and you are really dumping on them. Like Harshad Mehta case, people thought they will become millionaire overnight, similarly biodiesel fooled the farmers, people and industry. My feeling is, whenever you want to on big way such policy initiatives should be taken in cautious manner. Various state governments also setup the task force to work on jatropha. In the first meeting 2004, I told Andhra Pradesh chief secretary, at that time lots of farmers suicide were happening, at that time the government thought the biodiesel is boon. I told them we should not go with this speed for biodiesel; first select the 8-10 districts, plant jatropha of different varieties and generate the data for first five years. If you find it successful then only you go to the farmers. They said no, my chief minister wants it immediately; and, within three years Andhra government withdrawn jatropha.

From the above discussions on financial support and price mechanism concerning biofuels in India, we can point out that research and development, and popularization of jatropha started simultaneously in India. Perhaps this constitutes one of the reasons for failure of adoption of the jatropha plantation as a source of bioenergy nationwide. Various stakeholders including the farming community were not backed with the effective research findings, market and price mechanism, as it was too early for the research findings to be crystallized and extended to the farming community. Overall this section discussed the various facets of materiality of jatropha manifested in scientific practice and when it enrolled in the structures of institutional mandates, collaboration and market mechanism. In the next section, we attempt to understand the discursive flexibility of jatropha in the context of its promotion as a sustainable and renewable source of energy for India.

3.4 Discursive Flexibility of Jatropha

Borras et al. (2016) refer to 'flex crops,'[8] which have "multiple uses such as food, feed, fuel and industrial material that can be easily and flexibly interchanged". On the one hand, the promoters seem to be attracted to such material flexibility because it helps them decide what

[8] Borras et al. (2016) put the limitations for a crop to be treated as a flex crop. Crops with multiple uses do not automatically qualify for flexibility. They set three conditions to become a flex crop, namely – material basis, technological possibilities and profit viability. "If a crop or commodity use can be switched from one specific purpose to another with technical ease and with attractive economic return, then a link between multiple-ness and flexible-ness may have far-reaching political economic implications."

to produce and sell based on price indications that enables them to diversify markets for their investments while dealing with a single crop (ibid.). While materialist explanations of crop flexibility are crucial to understand the political economy of contemporary agrarian and environmental change, they can be further enhanced by examining the shifting and interacting discourses around these flex crops. Indeed, these are usually not presented as 'crops' at all, but rather as a means of achieving food and economic development, enhanced rural livelihoods, energy security, climate change mitigation, etc.

Flex crops embody multiple implications to food security, climate change and variability, and to the livelihood of peasants, pastoralists and indigenous peoples. In addition to material flexibility, flex crops are subject to what Hunsberger and Alonso-Fradejas (2016) call "discursive flexibility – the ability to strategically switch among multiple discourses which construe the necessary meanings and representations to achieve an objective". In this section, we examine the discourses that state, scientific community, NGOs, corporates and social actors employ to legitimate the promotion and expansion of jatropha, and how these discourses are initiated to bring in discursive flexibility, and how material flexibility or inflexibility in some instances interacts with the discursive flexibility of this crop. We discuss how discourses are strategically formed, activated and signified in the context of consensus and contestation among various actors, and as the outcome that material and discursive flexibilities complement and reinforce each other in the case of jatropha in India.

Policy networks, in our study on biofuel policy networks, incorporate a variety of government agencies, key legislators, pressure groups, relevant businesses and industry representatives, consultants and policy analysts and journalists, through which policies are forged (Scoones 2006). To extend a policy, research project, or development initiative to other spheres, networks require actors who are protagonists or "policy entrepreneurs" (Hart and Victor 1993). These actors play "crucial roles in publicising an issue, succinctly defining the urgency of a problem and offering the possibility of a solution" (Latour 1996). Policy decisions do not automatically reflect evidence gathered to inform decision makers. Rather, 'science' may align with vested interests, is formed within and by various networks to legitimise, or in cases can be entirely neglected.

3.4.1 Promotion of Jatropha in Discursive Network

As we have discussed in previous sections the tree-borne oilseed shrub jatropha has been promoted as a solution to problems of climate change, rural poverty and food insecurity, and it has spread rapidly in the global South (Dauvergne and Neville 2009). Jatropha does not have the high material flexibility as it cannot be consumed as food, and can only be made into livestock feed if it is first detoxified, unlike other potential sources of biofuels, viz. soybeans, palm, coconut, groundnut, etc. While proponents of jatropha claim that production of oil from jatropha results in various other co-products other than the oil which has market value, and it has a characteristic of dependency among multiple value chains rather than independent value chains.

Despite this low material flexibility which is emerging from the dependent value chains jatropha has been the subject of multiple discourses that actors have used to promote its expansion. The actors selectively promote and combine particular discourses to build and maintain momentum for jatropha's spread. In the following sections we examine multiple claims about jatropha's uses, purposes and representations, and show how the fluidity of these claims has shaped its expansion. After reviewing a series of legitimating discourses that have been attached to jatropha, we draw upon the interviews with key actors such as the scientific community and officials in the biofuel network in India to present three examples of discursive flexibility in action for jatropha, and attempt to show how despite with the limitation that discursive flexibility may have amplifying effect on other edible oils, it has a compensating effect for jatropha owing to its low material flexibility vis-à-vis other edible oils.

3.4.2 Legitimating Discourses around Jatropha

Jatropha's supposed ability to thrive in harsh environments and its non-edible character are two elements of its materiality that have helped buttress legitimating discourses. Many of the positive claims about jatropha's potential have been challenged by research in numerous countries (Kant and Wu 2011) and NGOs (Friends of the Earth 2009; WWF 2009). Nevertheless, optimistic scenario still persists and is presented by some efforts to establish

long-term projects of jatropha cultivation (Nielsen et al. 2013; von Maltitz, Gasparatos, and Fabricius 2014). Our attempt here is to demonstrate how various narratives of jatropha as a means to achieve clean energy, food security, environmental improvement and poverty reduction have been employed to promote the crop.

Jatropha protects food security

Biofuels have been strongly criticized for threatening food security. While jatropha has faced attack on this front (e.g. Friends of the Earth 2009, 2010; Shiva 2015), a continuous legitimizing discourse states that jatropha can circumvent the 'food versus fuel' critique for two main reasons: (a) jatropha is expected not to compete for land and water with other food crops owing to its ability to grow in nutrient-poor and dry soil; and (b) as a non-edible crop, it would not cause food to be directly converted into fuel unlike maize, sugarcane, oil palm, etc. (Francis, Edinger, and Becker 2005). Further, some claimed that growing jatropha would improve rural food security by providing a micro-climate that would help food crops grow where conditions would otherwise be too harsh; protecting food crops from animals when grown as a fence; generating income that could be used to purchase food; and providing a local energy source to improve food processing or storage (Achten et al. 2010). Together these arguments helped jatropha assume 'sustainable' status among sources of biofuel. According to one of the respondents from the Indian Institute of Science, Bengaluru:

> We are ranked one in biosynthesis potential of the land. If we use the Gangetic plain, we can produce enough food for the whole world. The farmers need income other than food. If they produce oil with the remaining potential which is not being used for the food crops, can be diverted for the oil production. We have an issue with market, if the production is more the prices will go down. Even in such cases if they produce both, they can get the price for both the food and the fuel. There are only a few countries in the world those have larger area in than us. But, other countries have limitations in their resources, like China and Australia have huge area but considerable amount of the is not arable. Similarly, in the US, sufficient number of people are not there to get engaged with the available land. In India, we have sufficient amount of land and sufficient number of people for the agriculture. And we are correctly located in the latitudes, i.e. tropic region where we get a good rainfall and sunlight.

Moreover, the National Policy on Biofuels (GoI 2009) states that in the light of food security and poverty concerns, jatropha "stands out among others as the primary non-food biodiesel

crop that will be promoted for development in the bio-diesel industry" (ibid.). India's biofuel policy also encouraged non-edible oilseed cultivation on 'wastelands', implicitly favouring jatropha (Baka 2013). As policymakers have increasingly shown awareness and concern about the potential negative impacts of agrofuel production on environments and livelihoods (Bailis and Baka 2011; Hunsberger et al. 2014; Shukla and Mallick 2017), jatropha's 'sustainable' potential continues to be reflected in biofuel policies.

Jatropha and material flexibility

Matrerial flexibility of jatropha can be analysed against the backdrop of its promotion. How flexible is jatropha in a material sense? On ecological aspects, jatropha is not perforting upto its reputation, producing lesser seeds under dry conditions as compred to what was claimed (Nielsen et al. 2013). It cannot be easily flex in the sense of producers or investors deciding which of several products to make from it. Jatropha oil can be used to produce soap if not biodiesel, but looking at the present infrastrcture of soap production, large-scale soap production is unlikely to emerge as an alternative value chain, however, it has long been used around the world as a source of lamp oil and soap, and as a hedging plant (Kovarik 1998). Jatropha oil can be directed toward various energy applications, but the different infrastructure needs of each pathway make it less likely that crude vegetable oil and biodiesel could be easily interchanged. Such limitation in interchangibility can be captutured from the explanation of one of the participants from CSIR-Indian Institute of Chemical Technology, Hyderabad:

> About 65 percent of our requirement we are importing from Malaysia, Indonesia, Russia, the US and European Union. We do not have oil to eat, then why we will go for some oil which is highly toxic. If I would have in the position to take policy matters, I would have gone for an oil which is edible. If there is surplus then we can produce biodiesel from edible this oil. If biodiesel doesn't fit in the economy we will eat it. why we have to go for jatropha which is toxic. If we cultivate jatropha for producing biodiesel, and production of biodiesel is not economically feasible, then what will happen to the feedstock. A jatropha seed contains one third of oil and two third cake, that is waste and very toxic. If you go to adivasi areas, if you see them, they do not go near this plant, because they know this is a toxic plant. Why would I go for a toxic variety? If I have some land, I will cultivate some edibles. Our import will be reduced. We want to produce biodiesel by importing edible oil from Malaysia and Indonesia. We are replacing our foreign exchange of biodiesel by foreign exchange from palm oil,

> why? If you ask me I would never go for jatropha. In our country some of the regions are suitable for palm cultivation. The government can go in the direction of producing vegetable oils. There is a possibility of failure due to fluctuation in price of crude oil. Even at the time when the price of crude oil was very high, we were unable to compete with our biodiesel. Now the price of diesel has been come down, and now nobody is interested in producing biodiesel. Such situation I can predict being a scientist, big economists are there, couldn't they predict? They have some vested interested, it may be monetary as well.

Further, all energy uses would be affected by the same fluctuations in fossil fuel prices, thus, shifting from biodiesel for transport to crude oil as a kerosene substitute would probably not improve a seller's position with respect to prices.

Selling byproducts is essential for jatropha energy production to be economically viable without subsidies (Pipal 2012), but this type of multiple use should not be mistaken for flexibility. If economic success relies on having not only one product, but two or more value chains operating simultaneously, then what looks like diversification may reflect a codependence that does not increase investors' freedom to switch between end products. So far, this question remains hypothetical since markets for most of the anticipated co-products like manure cake have not yet emerged. For instance, the relationship between jatropha's by/co-products and market value chain is explained by one of the respondents from the Karnataka State Biofuel Development Board (KSBDB), Bengaluru:

> When farmers grow there must be a market system, without market system farmers cannot do this plantation [jatropha plantation]. So, for the market if you have continuous production from various sources then there will be a market. The market can also happen locally, like for example they can start using these feedstocks by themselves. They can use the seeds, crush them, use the oil cakes as manure for to improve the soil. Farmers might expect this approach when it is supporting their agriculture, because soil fertility will lead to increased crop yield. The other thing is oil, the oil which they can use it or sell it. We have some regular small industries which can crush the seeds and produce oil and oil cakes. And through some of our programmes we are promoting small machineries which can be operated at villages under single phase power supply.

Intrestingly, another participant from the University of Agricultural Sciences, Bengaluru – not very far from the above one from KSBDB and both of them are collaborators – contested to such material flexibility:

> In Karnataka, the traditional oil seeds are available like *Neem*, *Mahua*, *Simarouba*, *Karanja*. After the oil expelling the cake we are getting, is one of the very good organic manure. We also know that these plants are leguminous in nature. In the case of jatropha, this is the disadvantage. Whatever cake we get from jatropha seed expelling, it does not enrich soil coppered to leguminous plants. Moreover, jatropha cake is acidic in nature, which is not good for fertility. Therefore, we have given the importance to our traditional plants instead of jatropha.

Jatropha and discursive flexibility

Actors associated with jatropha promotion have shown remarkable flexibility in producing and maintaining positive representations of the crop. Some of the promotional claims on biofuels are as follows:

> …Kyoto Protocol cannot be achieved without providing a large role for biofuels by 2050…[Biofuels] are appropriate for […] their simplicity; […] production via well-known agricultural technologies;…potential for mitigation of climate warming; …the use of existing engines;…their potential to facilitate worldwide mobilization;…their potential as a directly available energy source with good public acceptance; a common set of regulations;…their potential to create benefits for rural areas, including employment creation
>
> (Singh et al. 2014).

Jatropha has been promoted and developed by the biotech industry and policy actors as an allegedly sustainable alternative to fossil fuels (Carolan 2009b; White and Dasgupta 2010). However, during the past decade (1995 onwards) other actors have voiced concerns about potentially detrimental social and environmental effects of large-scale biofuel production(Shinoj, Raju, and Joshi 2011; White and Dasgupta 2010). In 2007 the 'fuel versus food debate' highlighted a link between the increased use of bioethanol in the USA and rising food prices in the world market (Paarlberg 2010). However, it is claimed that the Indian approach to biofuels is somewhat different to the current international approaches which could lead to conflict with food security. "It is based solely on non-food feedstocks to be raised on degraded or wastelands that are not suited to agriculture," thus avoiding a possible conflict of fuel vs. food security (GoI 2009: 3). However, the persistence of optimistic messages in the media (McGrath 2013, The Ecomnomic Times 2018) despite increasingly

critical research findings suggests that neither of these perspectives has become dominant over time.

3.4.3 Discursive Flexibility in Action through Consensus and Contestation

There are various discourses of jatropha-led development in India that are articulated by those responsible for promoting and regulating such process. In this section we examine two major discourses. One of these discourses promotes large-scale production to meet national objectives, drawing on themes of foreign exchange, national poverty alleviation, global climate change, and fuel blending. Another discourse advocates small-scale cultivation to support the farming community or household objectives, drawing on themes of income generation, soil improvement, value addition and rural energy access. On the basis of these two discourses, jatropha can be portrayed as an instrument of both market-led national economic growth and community-led rural development that helps us explain why it appealed to actors with widely varying priorities. This multiplicity of discourses (Hilhorst 2001) created an opportunity for actors to strategically choose which discourse to activate in which situations, maintaining a creative flexibility to link discourses together or shift between them.

The following cases illustrate ways in which promoters of jatropha took advantage of discursive flexibility. These can be grouped into two broad categories: the first (Case 1) represents end uses of jatropha by deploying particular narratives while dissociating from others depending on the circumstances, and the second (Cases 2 and 3) deals with conflating discourses that may be contradictory.

Case 1: Shifting narratives of jatropha's purpose

In this case we examine the shifting narratives of jatropha promotion with the excerpts obtained through interviews with scientists engagged in jatropha research at CSIR-sponsored Central Salt and Marine Chemicals Research Institute (CSMCRI)—Bhavnagar, India. Actors who changed how they presented jatropha's purpose over time provide one example

of discursive flexibility. Initially jatropha was adopted as a crop for 'improvement'[9] of land by a research institute supported by the Government of India. The western part of India with lesser rainfall has less intensity of vegetation and researches were trying to 'improve' the condition of landscape by adopting some measures. These measures were searching for the plant with specific characteristics which could sustain in semi-arid region with low water requirement that could withhold soil from erosion, improve the nutrients level of soil, and have a considerable life span. This searching task was executed by the CSMCRI. The scientists identified jatropha and pongamia having the characteristics to grow in wasteland and simultaneously improve the land. Later, jatropha was planted in Gujarat—Western India, and Odisha—Eastern India with the funding of the United Nations Development Programmee (UNDP) in 1996. The results of plantation were optimistic for future coverage on other part of semi-arid regions of India. Meanwhile, some state governments, oil marketing companies and research organizations started taking the interest in jatropha promotion. Daimler-Chrysler used jatropha oil in Mercedes Benz and ran about 10000 km and was satisfied with engine performance. D1 oil, a United Kingdom oil firm, collaborated with CSMCRI and the government of Chhattisgarh for oil processing and distribution, and various other State governments proposed enthusiastic plans for the plantation, promotion and distribution. The CSMCRI received funds from UNDP to cultivate jatropha at modest scale. But, the purpose of plantation was not for biofuels, rather to 'improve' coastal areas, sand dunes and 'waste lands'. Later it was followed by appropriation of land after the improvement. Nonetheless, the fact that Jatropha lived up to its reputation as a shrub that could eke out a living on relatively 'barren' land piqued the interest of India's Department of Biotechnology, which provided a modest funding for further exploration of biofuels possibilities using cuttings from three of the most productive plants in the UNDP trial, namely: Navsari, Chhatrapati and Hansraj.

Case 2: Portraying different approaches as co-dependent

Actors who present large- and small-scale jatropha production as mutually dependent illustrate another form of discursive flexibility. Several interviewees (56 per cent) state that

[9] Idea of 'improvement' and related 'wasteland' development discourse have been discussed in length in the Chapter II.

small- and large-scale approaches to grow jatropha would stimulate and mutually reinforce each other. Some describe (18 pec cent) how large investments could build processing capacity, raise interest among potential buyers and encourage more farmers to plant, thus building momentum that could in turn enable smaller projects. One researcher from the University of Hyderabad, states that large projects, if successful, could provide examples to motivate and support small initiatives. Another respondent from the Indian Institute of Science, Bengaluru, said this when asked what would be the best approach to growing jatropha in India:

> Earlier we used to preserve seeds for the next season/year cultivation. After the introduction of hybrid seeds, we cannot do this. The seeds can be preserve for next cultivation but these seeds will not give that much production. So, every year we have to buy new seeds. But hybrid seeds give good production and some certainty is also there. These days most of the people prefer hybrid seeds. Those do not have resources and proper income they use ordinary seeds. Harvest from these both varieties of seeds is almost similar. But the hybrids give more production. Generally, when we use the preserved seed, it requires around twenty katha[10] of preserved seeds, on the other hand only ten katha of hybrid seeds are sufficient for one acre. The quantity of both the types is different because germination rate is different. As the price of hybrid seeds is increasing continuously people have become conscious over the quantity they are purchasing and production they are getting. They have improved [changed] their method of cultivation. Whoever is able to plant more, let them plant because until we get a critical mass we cannot talk about jatropha as a business. At the same time, the villagers who can get a few kilos, extract oil, they can use them for local lighting, for the stove and all that. So to me, a hybrid would work very well.

These comments imply that it is not only feasible but necessary that small- and large-scale production should occur side by side. Two distinct approaches – articulated as commercial production led by the corporate, private sector and livelihood-oriented production for local use – are portrayed as not only compatible, but interdependent. Combining approaches together in this way create the impression that jatropha would necessarily achieve a wide range of goals.

Case 3: Blurring discourses

[10] 1 kaathaa = 3 kilograms

In contrast to local production for local use, some actors promote an outgrower role for small-scale producers. Typically, an outgrower arrangement involves small-scale farmers producing a crop on their own land under contract for a company that also operates as a nucleus plantation. For instance, private industries like Emami, Reliance and D1 oil have contract with the farmers in Chhattisgarh (Source: Field data). This means inserting small-scale producers into a commercial value chain where they would sell jatropha seeds into a centralized system for cash. Several interactions with the participants drew parallels between a potential jatropha industry and existing systems of cotton, sugarcane and vegetable production, presenting these as examples of how large and small farms could successfully coexist.

The outgrower production model appears to offer a different kind of 'win–win' situation than the parallel advance of commercial and local production just described. Those who espoused the outgrower approach described it as able to achieve multiple benefits: ecologically, small plots would be preferable to large, monoculture plantations, while in terms of land tenure, farmers would keep the title to their own land – an arrangement that might appeal to smallholders while sparing investors from controversial negotiations over land (Pipal 2012). An outgrower system could also achieve the economic objectives associated with large-scale, centralized production. In this way, some promoted a nucleus–outgrower production model as compatible with many goals of both large- and small-scale approaches. But enlisting small-scale farmers as outgrowers is not the same as producing energy to meet local needs. An official from the Chhattisgarh Biofuel Development Board expressed doubt that an outgrower approach would benefit small-scale farmers:

> A large quantity of seeds started to coming to market. Initially people were buying these seeds as planting material, though we had already informed them that we are developing new seeds for the planting purpose…Some private companies like Ruchi Soya, Reliance, Emami, D1 oil purchased seeds from here. They purchased the seeds in large quantity and high price. As later on demand of planting seeds decreased, subsequently, the price also went down. But still price of the seeds is Rs.15 per kg, because the demand is still there, otherwise the price would have decreased more. Now people know the usability of jatropha, how oil can be extracted and used as diesel easily. To prove that oil can be used as diesel, we installed our own plant in 2005. No one wants to set up a plantation where he will have to spend so much money and receive so little yield.

> So what they will opt to do is have outgrowers grow it for them, and then they'll source it from the outgrowers, and then put punitive measures to make sure they receive the maximum out of that… How long will it take for a farmer to pay off his debt? It's a very risky thing.

Considering the nature of agricultural pursuit in India, new technology enters farm economy through large size holdings. Large holdings have investment potential, capacity to bear risk and reasonable size of holding to afford the use of mechanical power, which is invariably raises the income of the farmers who employ new technologies (Ray 2012). The crop will not be profitable to farmers having small land holdings owing to expensive management (Shukla and Mallick 2017). Farmers who are growing other crops and jatropha as secondary crop can expect good returns. Actors who promote the outgrower model portrayed jatropha as good for small farmers and good for the country, while glossing over risks that small-scale farmers would likely face. The discursive flexibility here lies in portraying one production model (the outgrower model) as achieving both large-scale and small-scale aspirations simultaneously without acknowledging that many of the unique benefits of small-scale production for local use would no longer occur. Instead of two coexisting approaches that would each achieve a discrete set of goals, this position merges them into one that could supposedly do the same. Conflating multiple goals in this way makes the spread of jatropha harder to contest. In the following section we will discuss the material flexibility of jatropha in response to environment discourses.

3.5 Discursive Flexibility of Jatropha in Environment Discourses

Environment discourses typically represent biofuels as a sustainable and clean source of energy vis-à-vis prevalent fossil fuels. Biofuels are also portrayed as panacea to multiple challenges, viz. climate change mitigation, international trade deficit, energy crisis, unemployment and rural development—especially in developing countries like India. As we have pointed out in Chapter II, the projection of World Energy Outlook (IEA 2013) estimates the rise of 56 per cent in global marketed energy consumption from 2010 to 2040. And, in continuation with the earlier projection the recent report (IEA 2018) states that

around 93 per cent of the world's carbon capacity[11] is already in use up to 2040. This implies that there is a little space for future fossil fuel projects to be developed over this period without contradicting international objectives around climate change.

India has been promoting biofuels under the larger ambit of renewable energy sources since late the twentieth century. However various concerns over the adoption of biofuels and its diverse social and political implications have been raised, both in India and the world over. Against such backdrop this section attempts to understand the contested meanings arising out of the debates among the scientific communities engaged in adoption, promotion, and research and development of biofuels in India. Furthermore, this section examines the legitimising discourses associated around jatropha, and, how different conflicting agencies of biofuels embody the crop with several meanings, and in turn draw flexibility to strategically switch over the multiple objectives and challenges which are publicised in the biofuel policies. We argue from STS perspectives that jatropha credited with various objectives including improving environmental conditions has not been stabilised yet. Indeed, discursive nature of scientific-claim making in the promotion of jatropha only creates a space to compensate the consequences emanating from the jatropha cultivation in India.

3.5.1 Environment Discourses at a Glance

Biofuels present one of many enterprising but complicated technologies characterising what may be broadly considered the 'bioeconomy' – moving from the restrictions of the genetic revolution to wider perspectives of replacing the fossil-based economy with a bio-based one. From a broad economic perspective, the bioeconomy refers to a set of economic activities relating to the invention, development, production and use of biological products and processes which can contribute to socio-economic impacts on developed and developing countries (OECD 2009). Such interlinkages of idea of development, environment and technology, here biofuels represent a technological enterprise that can be traced back to the

[11] Carbon capacity refers to the level of carbon dioxide emissions that can be released without causing significant global warming effects. This means that there is a little space for future fossil fuel projects to be developed over this period without contradicting international objectives around climate change.

1950s when the natural world was perceived and established as a problem, unexploited natural resources by human interventions. By the 1970s the environment or nature suddenly appeared to be more fragile (Meadows et al. 1972). The Club of Rome came up with *The Limits to Growth* in the 1970s indicating that natural resources are finite and running out from demands made by human population – who were apparently exponentially multiplying (ibid.). This has had implications for the concepts like economic growth, development, modernization and technology. The theorist of development (e.g. Meadows et al.) took environment as an unsettling exercise from the hitherto existing notion of untapped natural resources now give way to more complicated and calculated measures like conservation, preservation and sustainability. This brings about an intellectual turn towards reconsidering economic growth with ecological vulnerability (Pepper 1996). And perhaps, Rachel Carson's *Silent Spring* (1962) accommodated ecological sensibilities in development initiatives.

In the further development of the interlinkages, international organisations like the International Union for Conservation of Nature (IUCN), United Nations Environment Programme (UNEP) and World Wide Fund for Nature (WWF) teamed up and came up with World Conservation Strategy (WCS) in 1980 imbuing the idea of development with environmental ideas under the term 'ecodevelopment' coined by Maurice Strong. The WCS report came up as the *Our Common Future* and has referred to as the Brundtland Report published in 1987 that provided a compelling definition of sustainable development.

> Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth. The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations fora better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes.
>
> (WCED 1987: 8)

While the WCS was premised upon the belief that the conservation of ecosystems was crucial to sustaining development, the Brundtland Report reversed the claim by suggesting instead that the socioeconomic betterment of population would result in better conserved and managed ecologies. Thus, with such a change in emphasis, the Brundtland Report made a broader appeal to governments and policymakers. But, as Shiv Visvanathan (1991: 383) points out, in insisting that development, once again, be put at the centre of addressing environmental concerns, "deep down, the Brundtland Report still believes that the expert and the World Bank save the world." Such critiques have obvious implications on the greening the idea of development for the developing countries (Adams 2001) which was pushed through expert led policy and good science, rather than no transformative change, no political or radical struggle and challenges to the intellectual shift in environment and development.

Within this broader discourse of environment, development, and technology, we attempt to frame biofuels in the global assemblage which had created an enabling environment for the adoption of biofuel production the world over. This assemblage and need for biofuels in India can be traced from the response of a scientist from ICAR-sponsored Natural Resource Management Division, New Delhi:

> There are various countries who are in advanced stage of biofuel production from corn, sugarcane, palm oil etc. like in Brazil, the USA, the EU countries. But still we went for different approach for biofuels. Why we went ahead with tree borne oilseeds because of food vs. fuel debate. From these debates or from the problems other countries are facing, a lesson learned from others' experiences and we framed our biofuel policy in different line. There are two points which are clearly mentioned in the policy. The first is, we should not go for food crops like soybeans, corn, etc. for biofuel production, and the second is, we cannot target the prime agricultural land. For the purpose degrade land, marginal soil and land are to be targeted to avoid the conflict between agricultural land and biofuel feedstock. Therefore, in the biofuel policy it was clearly mentioned that one cannot cultivate biofuel crop in their agricultural land.

However, concerns were being raised by the UN, FAO, OXFAM, local NGOs, and researchers about the environment friendly production process of biofuels, and that arable land was being diverted for biofuels production which was in turn raising food prices

(OXFAM 2008). The development of biofuels is involved in debates on monoculture, food versus oil, land grabbing, and the not so green production of biofuels (ibid.). Various actors from research organisations and NGOs, farmers, and labourers raised issues of concern which were in opposition to the goals and claims of the development initiative. For example, according to one of the respondents from the Indian Institute of Science, Bengaluru:

> Jatropha alone is not a suitable crop to sustain the biofuels demand. Other countries are not dependent on jatropha only, they are using some edible oil also, like Malaysia is processing palm oil for biofuels. Though we are not using the edible oil, but surely we can diversify the feedstock by including other non-edible crops.

As we can observe from the those two responses from the scientists mentioned above, concerns are emerging on the viability and sustainability of biofuels globally, voices of skepticism are also arising in India on the production and viability of biofuels (see also, Ariza-Montobbio and Lele 2010; Baka and Bailis 2010). In the following section we bring up the narratives about biofuels as renewable, sustainable and clean energy, and how these have played a pivotal role in enabling recent jatropha projects in India even after or in the midst of skepticism of biofuels' trajectory.

3.5.2 Jatropha as Renewable and Sustainable Source of Energy

Jatropha has gained from the general view that biofuels can help mitigate climate change and enhance energy security (e.g. IPCC 2011) as well as the more specific claim that energy crops grown on 'wastelands' do not incur a significant carbon debt and it is a path toward 'low-carbon economy' (Fargione et al. 2008; Walker et al. 2010; Romijn 2011). Such claims on carbon reduction can be examined through in an interview with a scientist from the University of Hyderabad:

> We are focussing on how a plat fix the atmospheric carbon dioxide and what quality of biomass is produced. We are engaged in such work from almost thirty years. Later we got a project from DST-DBT, they asked us instead of looking other plants, to look this phenomenon in biofuel plants, whether these plants take up the carbon dioxide and convert into oils. So, my lab is interested in basically

> two aspects: carbon fixation and oil production. We go for trees which can fix lot of carbon dioxide. carbon dioxide level has increased to 400 ppm, and as the carbon dioxide increases on atmosphere, temperature also increases. What we propose, we should look for those trees which can fix carbon dioxide and at the same time biomass can be treated for biofuels. In this context we proposed jatropha and pongamia. Fortunately, we identified jatropha among many species. It can fix a lot of carbon dioxide in comparison to other trees.

On a similar note, a senior scientist from ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, concurred his opinion on land use for the cultivation of biofuels:

> If we go for large scale plantation jatropha can fix the rising carbon dioxide problem. For this we need marginal lands or wastelands, other agricultural land should not be used. Now the question is, whether jatropha can be grown in marginal lands as it is or not? It cannot be grown on marginal lands without care, but it has to be managed. Jatropha has potential to produce lot of oil and carbon dioxide fixation. If you can provide some care to the plant and wait then it is very useful.

Jatropha's carbon balance has been favourably compared to that of fossil fuels as well as other biofuels, as long as it is not cultivated on farmlands and woodlands (Bailis and Baka 2013). The claim that jatropha has low land-use impacts and resource-input requirements has helped support the idea that it is more sustainable than other sources of biofuel.

Discussions about jatropha's merits and problems as an energy source tend to cluster around two scales. At global the level, airplane test flights that ran partly on fuel derived from jatropha raised hopes that in time, jatropha oil could help reduce emissions from the aviation industry (Jha 2008). Many projects have promoted jatropha as 'clean energy for development' at the local level, hoping it would provide off-grid power for small engines like irrigation pumps and grain mills (Achten et al. 2008). At the household level, jatropha has been projected to produce less smoke than fuelwood or charcoal (for cooking) and kerosene (for lamps) although others report more mixed results (Nielsen et al. 2013).

Environmental discourses centered around jatropha portray it as a tree rather than a crop or an energy source. As such, jatropha has been linked to a reforestation narrative and included in tree-planting projects that aim to earn carbon credits (Walker et al. 2010). In addition to

expanding or restoring forest cover, some claim that jatropha can reduce deforestation owing to its roots' capacity to firmly hold soil and pruned branches can provide shelter to other plants and it is helpful in the situation of flood and draught (Achten et al. 2010). One of the scientists from CSIR- sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar, mentions about the robust character of jatropha that "*jatropha is a very hardy plant. The Berhampur plantation along the Bay of Bengal has sustained two super cyclones*". Another scientist from the same institute has similar opinion but on different aspect:

> New scenario is searching for new sources. Our prime minister has talked for solar energy on various occasions. From media what I am getting is solar energy is coming very fast, but other things are also going in parallel. Which one is sustainable for us, I cannot say? What we thought about biodiesel, it did not pick up. If you talk about solar energy it seems very well, but it will not help environment. With biodiesel we can support our environment and make it green.

The Director of the Chhattisgarh Biofuel Development Authority comments on the enabling aspect of biofuel production with reference to environment suitability and economics of jatropha:

> After installing the plant, we proposed same to a few private companies. But the government did not come with clear policy. With all the characteristics of environmental friendly like no Sulphur, no Lead, low viscosity, optimal pour point, safe flash point, and no pollution. We were producing biodiesel from jatropha, and the new government did not allow us to sell the same in market. They said, you cannot sell it directly in the market. Then, to whom we should give? If you supplement environmental economics, which was not considered while calculating its economic viability, with other benefits from jatropha it is quite possible to go ahead with this biodiesel crop. If you add up the environmental economics that how we are decreasing the pollution and what is the cost and implication of the pollution, nobody has done that. If that is being done what would be the net cost.

Jatropha has been credited with improving local environmental conditions in other ways: by controlling erosion, enriching soils, promoting water infiltration and reducing floods. These functions are sometimes framed as reclaiming or restoring 'degraded' lands (Francis, Edinger, and Becker 2005). However, opponents of a proposed plantation in India contested

the project using a counter-discourse that portrayed jatropha as a threat to biodiversity (Calvert et al. 2017).

3.6 The Scientific Claim-making: Consensus and Contestation?

In this section, we attempt to understand the conflicting perspectives within an organisation, presented as consensus of the organisation to the receivers such as apparently the farming community as the receiver of scientific knowledge. This knowledge is presented in coherent and straightforward way to outsider. This selling of dissent among the scientific community as consent is extended as per technocratic processes and mandates of the organization, viz. mandates of CSIR, ICAR, DBT, etc. on biofuels research. For example, how institutional mandates reflect in unexpected turns and outcomes of research projects, and the same can be observed in the response of a senior scientist from CSIR-National Botanical Research Institute, Lucknow:

> I am not very sure about policy, but we started working for jatropha in 2005 and very much engaged in it till 2013-2014. We were mainly engaged in exploring the various environmental factors which could affect the plant, collection of germplasm, conducting field trial, and accessing the suitability of the plant for various regions especially for draught prone areas. The projects related to jatropha were short lived as compared to other projects we were engaged with. We can say its total failure main reason was economic viability, nothing to do with oil part/content. In research point of view, one cannot expect results in short duration, we should have patient for substantial outcomes. Now the mandate is shifted to biofuels from algal, but personally I feel algal is not viable for India.

Technocratic process embeds the epitomizing of valuing knowledge placed within the rigid cognitive system, excludes many local practices and actually establishes an "ideology of extension" (Desai 2006). Knowledge is not understood as "neutral" but as part of a power field that is continuously transformed and redefined by ongoing discourses and hegemonies. As Bruno Latour (1987: 133) writes, we should not forget "the many people who carry (ideas and technologies) from hand to hand", we should turn toward the network and translation processes that form the arena in which these ideas are moved about. And in this process in spite of obvious hegemonic dynamics produces pluralities that should not be ignored. In this sense knowledge should be seen as a "set of practices" (ibid.). Significance of practices and the daily reality of laboratory process can be compared to what Pickering (1995) has called

the "mangle of practices". With the concept of 'mangle' Pickering offers a new approach to science and unpredictability of change that comes within it.

Drawing parallels to Pickering's arguments the opinions on the merits and potentials of biofuels become strongly polarised. Public debates around the world contain both optimistic praise for and pessimistic warnings against biofuels as a substitute for fossil fuels. Participants in these debates make reference to and claim support from scientific knowledge. However, it is difficult for both the general public and decision makers to discern what should count as well-founded knowledge or not in these different claims and scenarios. It is therefore pertinent for STS to explore what role science – "the conventional arbiter in disputes about factual matters" (Hansen 2014: 74) – plays in the controversies around biofuel policies. Hansen complements the existing literature with more detailed attention to the scientific dimension of the controversies about biofuels. It follows the scientific uncertainty and incomplete knowledge bases, in particular in domains such as nuclear power, solar energy, climate change and biotechnology. The opinion of one of the scientists from CSIR-Central Salt and Marine Chemicals Research Institute, Bhavnagar, draws attention on choice of an energy source:

> Because vegetation [which is supposed to spread by jatropha plantation] is required for environment, in barren land, and if you plant something over there, it definitely helps microbial flora fauna and also provides shelter to animals of the area. It also helps to reduce environmental pollution and soil erosion. Jatropha is very good plant for wasteland, but there is a myth that jatropha produces a good number of seeds. Though it can grow very luxuriantly in wasteland, rocky land and other different kind of land. We have tasted this in all over the country, it grows very well. But what happens, it also requires a good amount of inputs in the form of water and nutrients for healthy and good production. So, there is a limitation with the plant. If you do not want any production it is good, but if you want good production you have to plant some selected one. It requires elite plants, then only you can get good production.

She further emphasises on the politics of choice:

> The national agenda for biodiesel has been changed, new scenario is searching for new sources. Our prime minister has many times talked for solar energy. From media what I am getting is solar energy is coming very fast, but other

> things are also going in parallel. Which one is sustainable for us (India) I cannot say? What we thought about biodiesel, it did not pick up. If you talk about solar energy it seems very well, but it will not help environment. With biodiesel we can support our environment and make it green.

Some observers suggest that scientific uncertainties are often the cause of political controversies over novel technologies (Winner 1980; Beck 1992). Winner attaches inherent political attributes to technologies. In other cases it has been suggested that political competition is likely to fuel scientific controversy (Jasanoff 2004). Combining these perspectives, an influential contribution suggests that the boundaries between science and politics are eroding (Nowotny, Scott and Gibbons 2001).

The contestation between various scientific claims can be categorized into three conflicting perspectives about biofuels. First is a "reductionist bio-processing" perspective emanating from biosciences and bioengineering disciplines, here changes at molecular level directed towards achieving divergent application of biofuel sources. Second is "holistic bioscarcity" perspective emanating from ecology and life-cycle analysis (Hansen 2014). This perspective focuses on the adverse consequences of biofuel on ecological cycle. And, the third perspective has apprehensions over adoption of biofuels in either situation. This perspective is in favour of biofuels as a product of biomass at the rural level but not for mass production at the industrial level.

For bio-processing perspective the guiding vision is: bio-processing as a generic process technology, where any biomass can be transformed into a plant-based equivalent of crude oil. This suggests that plants are a most powerful capturer of energy from the sun through photosynthesis. Important scientific progress has been made recently in extracting this energy through various biochemical process technologies, in particular enzymatic degradation of celluloses. One of the researchers from the the Indian Institute of Science, Bangaluru has opined the similar approach for biofuels in India:

> We are ranked one in biosynthesis potential of the land. If we use the Gangetic plain, we can produce enough food for the whole world. The farmers need income other than food. If they produce oil with the remaining potential which is not being used for the food crops, can be diverted for the oil production. We

> have an issue with market, if the production is more the prices will go down. Even in such cases if they produce both, they can get the price for both the food and the fuel.

It is characteristic that the scientific claims of the bio-processors rely on a reductionistic 'building-blocks' metaphor, where scientific advances at the molecular levels allow for novel combinations based on organic matter to be scaled up in bio-process (Hansen 2014). Such bio-processes are projected to solve more macro-level societal problems via step-by-step expansion. When observed upwards from the molecular level, biomass is framed as an abundant and extremely flexible resource, and any potential scarcity is associated with suboptimal uses and regulatory rigidities. We can thus observe how authorised scientific knowledge generated at the molecular level is coupled with societal visions in two ways. On the one hand science-based projections are made about what can be done in future technological applications. These projections are not established scientific facts, but derive credibility from their scientific sources. On the other hand, the projections locate the responsibility for the realisation—or not—of future applications outside the scientific system and direct demands at policymakers. There is a noteworthy temporal dimension to this coupling: current research results are used to envision future technological applications, the realisation of which requires particular policy choices in the present (ibid.). This also illustrates the asymmetries between scientists and other policy actors, where scientific authority is translated into political credibility, which cannot easily be dismissed by non-scientist policy actors. For this, counter expertise in the form of alternative scientific perspectives and interpretations is required.

In "holistic bioscarcity" perspective, the scientific arguments articulated against biofuels in debates derive primarily from researchers with a disciplinary base in environmental science, ecology and life-cycle analysis. These scholars argue that although seemingly abundant at present, biomass will be a limited resource in the future. Depleting fossil resources have sparked emerging technologies in many sectors reliant on biomass such as fuel, heat and power, chemical engineering, etc. in addition to food production. Because these technologies develop in parallel, the central problem from a life-cycle analysis perspective is how to prioritise between different uses of biomass and avoid the detrimental knock-on effects of

land-use change in the developing world when demands grow in the developed countries. According to one of the scientists from the University of Delhi:

> If you start converting oil from soybeans or mustard you are taking away food in lieu of biofuel. So, biofuel is coming from food which is already in short supply. We import edible oil, for biofuel we need oil which is not edible. If we convert edible oil into fuel, we end up importing more and more edible oil. And edible oil is not cheap. What we look for an economic viable option for fuel, therefore that is another reason edible oil cannot be considered for biofuel, we need cheap biofuel. Biofuel from crops we need land, we cannot go for those land which are already being used for cultivation. What I need a plant which is not competing for land which is used for growing food. So, there are two things: first, edible oil is not an option and is not economic option, and the second, land issue, used for food crop. We will look for those lands which are not used for growing anything, which are wastelands. So, I need a crop which can be grown in wastelands. That is why jatropha was selected for fuel. But, again economics must be worked out. If I grow in road side, I need manpower to pick up the seeds, those seeds now extracted for the oils, and oil needs to be converted into biofuels. All these processes require money. And, even after you end up not getting quality seeds, you are spending more input costs than price of diesel. Jatropha has some stability issues. The biofuel is not very stable. So, in this area I was working on [if I can make it more stable] to make it more stable through increasing mono saturated fatty acids rather than poly unsaturated fatty acids.

In such analysis on liquid biofuels, whether first or second generation, does not perform well. Findlater and Kandlikar (2011) argue that even the theoretically maximum available biomass is going to run out long before we have fulfilled more pressing needs than road transport. The energy sector in the developed parts of the world is potentially a much larger 'customer' for biomass than the global food market. This implies that fulfilling even a fraction of the needs of the transport sector worldwide will demand a relatively large share of the areas needed for food production (ibid.).

Liquid biofuels are a primary object of technological innovation today, but from a life-cycle analysis perspective, road transport represents a suboptimal use of biomass. Furthermore, life-cycle analysts suggest that intensified biomass production is expected to produce a number of undesirable knock-on effects in terms of technological lock-ins, delaying the transition from combustion engines to electric or hydrogen-powered vehicles or even more substantial changes in infrastructure to lower the demands for individualised mobility. Also,

biomass shortages in the richer parts of the world are likely to call for imports from economically and ecologically more vulnerable parts of the world. A senior scientist from CSIR-National Botanical Research Institute, Lucknow, points out the limitations arising from economic viability and environmental implications in the context of India:

> Jatropha was taken back because there was no way how to harvest it. The plantation was labour intensive and costly. What inputs we were providing we were not getting back. That is why the government withdrew it. This was a fall, but, still I think jatropha is very good and a potential crop for biodiesel purpose. If you supplement environmental economics, which was not considered while calculating its economic viability, with other benefits from jatropha it is quite possible to go ahead with this biodiesel crop. If you add up the environmental economics that how we are decreasing the pollution and what is the cost and implication of the pollution, nobody has done that. If that is being done what would be the net cost.

There is some contention about how to delimit the systemic aspects of biofuels production and consumption. Nevertheless, the general consensus suggests that liquid biofuels constitute a suboptimal use of biomass. When bio-processors compare biofuels favourably to currently used fossil fuels, they ignore the fact that the same biomass could be used more cost effectively to reduce carbon dioxide emissions if applied differently (Dias et al. 2012).

The scientific perspective on life-cycle analysis thus moves holistically from a macro scale to consider biomass a scarce and fragile resource, depending critically on many interlocking factors in the production chain. This perspective compares the estimates of the energy available to extract from biomass, either at the regional or global level and the estimated energy required to refine it for different purposes. Though 60 per cent researchers in the present study disagree about the most suitable metrics for different problems, viz. energy balances, carbon dioxide removal, land-use change, etc. These arguments suggest that there is fundamental agreement among academic life-cycle analysts that liquid biofuel for the transport sector is suboptimal when taking alternative uses into consideration. However, the earlier agenda for this area was captured by commercial interests to serve as a ‘green agenda’ for the petrol industry, car manufactures and agriculture (Sarewitz 2004).

The internal differentiation of scientific communication suggests that the political struggles about biofuels are better understood as propelled by scientific diversity rather than scientific uncertainty. Scientific diversity (Hansen 2014) refers to situations where different but in principle equally scientific perspectives relevant to a given policy problem are propagated simultaneously, leading to different policy recommendations. Such differences of perspective are possible because of the disciplinary differentiation of scientific knowledge production. Rather, the challenges to policymakers and the general public are rooted in the fact that different branches of scientific knowledge bear upon complex policy problems in different ways, creating what Sarewitz (2004) has called an 'excess of objectivity'; which implies multiple, possibly conflicting, scientific claims are at the disposal of decision-makers simultaneously with no meta-criterion to adjudicate.

3.7 Conclusion

The aim of this chapter was to explore the interaction between jatropha and scientists from different perspectives. This chapter shed light on the diverse ways in which research and development of jatropha are catered in a variety of social, political and technological contexts. We focused on capturing the materiality and agency of jatropha, discursive nature of scientific claim-making in biofuel promotion or opposition. We found out the materiality and agency of jatropha do manifest in the process of dialectic of resistance and accommodation in scientific practice. The materiality and agency of jatropha can be observed in temporal and performative ways when it comes into interaction with other agents and structures enrolled in the biofuel network.

We have discussed that discursive flexibility has helped us make the 'jatropha project' resilient in the face of failure. Much of jatropha's discursive flexibility comes from the idea that it can achieve different sets of goals depending upon which production model is used. The cases discussed above demonstrate that actors in India equate large-scale jatropha production with national and international goals, small-scale production for local use with household or community goals and outgrower systems with 'the best of both worlds'. The idea that different outcomes (and benefits for different groups of people) can be achieved by choosing among several possible production models. Unlike the decision of which product

to make, the choice of production model must be made early on that involves considerable lock in. It is not easy to change between large-scale plantations, small-scale production for local use or nucleus-outgrower arrangements once they are underway. Invoking the flexibility of different production models is therefore a discursive tactic.

On the contrary, jatropha's low material flexibility appears to be a unique feature among agrofuel crops. As a few marketable products can be made from jatropha, and markets for these products are not well developed, it is not easy to shift from one value chain to another for example, from biodiesel to soap. For crops such as oil palm, energy production adds another layer to a political economy that already includes food, feed, commercial or industrial products.

In the section of scientific claim-making, we referred to Pickering's "mangle" in the process of resistance and accommodation performed by actants and actors and how they set the locus of any scientific experiment (Pickering 1995). Here we discussed the interlinking of discursive flexibility of jatropha and environment. We identified the presence of pluralistic narraritives in both propmotion and opposition of biofeuls in general and particularly jatropha in the case of India.

Paradoxically, jatropha's low material flexibility helped us position it as a 'sustainable' energy source. In terms of its ability to attract investor and government support, jatropha's high discursive flexibility seems to have compensated for its low material flexibility. On the one hand, the actors have been able to portray jatropha as capable of simultaneously achieving national or global goals related to economic growth and climate change, and, on the other, community goals related to livelihoods and local ecologies. Changing the stated reason for growing jatropha in the absence of a relevant value chain and conflating the expected outcomes of different production models provide examples of discursive flexibility at work.

In the following chapter, we will attempt to capture the responses of the useres of technology with special attention on the farming community engaged in jatropha cultivation. We will

attempt to examine the implications emanating from jatropha cultivation. In this procees there will be an attempt to juxtapose responses of the farming community and the scientific community against the backdrop of the interaction between the laboratory and the field.

Chapter IV

Narrating the Cultures and Sciences of Biofuels Production in India

Introduction

In the previous chapter we have discussed the interplay between jatropha and the scientific community through various dimensions such as the latter's efforts to domesticate jatropha, the development of varieties in order to make jatropha a disease immune and multilocation plant that can thrive in different geographic and climatic conditions. Then we discussed the materiality and agency of jatropha when it is at the research and development stage and, also when it gets 'mangled' in the larger and more complex biofuels network embedded in the institutional mandates, policy interventions, and the contours of collaboration, funding and pricing. We also discussed the discursive flexibility of jatropha with special focus on environment discourses.

In this chapter we move on to explore the impediments and risks involved in the cultivation of biofuels, particularly jatropha, from the perspective of the farming community. This chapter under the broader schema of third research question and objective of the present study engages with the farming community who cultivate jatropha in India. We attempt to juxtapose responses of the farming community and the scientific community against this backdrop: when jatropha has reached from the laboratories to the farmlands. In this process we draw from the social construction of technology (SCOT) to understand the farming community as the users of technology.

This chapter mainly banks on the responses of the farming community. A multi-sited ethnography was undertaken to understand the social order, practices, and daily life of the farmers and landless labourers who are / were udertaking jatropha cultivation. Ethnographic fieldwork methods have been in practice in STS scholarship such as Latour (1993; 1996), Cooper et al. (1995) and Downey and Dumit (1998) to demonstrate how power relations and cultural meanings are embedded in the adoption of technology. For the present study fieldwork was conducted in the states of Chhattisgarh, Madhya Pradesh and Rajasthan to interact with the farming community and representatives of private companies and NGOs engagged in jatroha's promotion, cultivation, and distribution. In the following section we introduce our field sites and rationale for opting them.

4.1 Introducing the Fieldwork Sites

In the National Mission on Biodiesel, 2003, rural development was one of the initiatives to improve livelihood of the rural areas (GoI 2003). As discussed in chapter II, cultivation of jatropha is either focused on the government-identified 'wasteland' and marginal lands, or lands of the farmers who show interest in the plantation. During the first phase of the NMB, biodiesel production was actively taken up by many state governments. Many state governments came up with different approaches and programmes to promote jatropha cultivation in their states such as linking the plantation with incentives and buy back support, linking the plantation programmes with state and national employment guarantee. Dwelling upon these programmes of the states falls beyond the scope of this study. We have mentioned the limitation and our approach to selection of field sites in the Chapter I. Here, in this chapter we focus only on the field sites pertinent to the present study, namely: Chhattisgarh, Madhya Pradesh and Rajasthan.

Chhattisgarh

Chhattisgarh was the first state to express an active interest in the biodiesel mission and was the forerunner in the advancement and uptake of biodiesel production in India. On 26 January 2005, the Government of Chhattisgarh established the Chhattisgarh Biofuel Development Authority (CBDA), which was designated as the primary organisation entrusted with the responsibility of promoting widespread plantations of jatropha in the state and producing biodiesel subsequently. In Chhattisgarh, the state government played a key role in promoting the cultivation of Jatropha and hence we trace the creation of the *government-led* biodiesel network in this state. In this state fieldwork was carried out in two districts ─ Bilaspur and Durg. Two regions were identified – Pendra, a block in Bilaspur district, and Godhi, a village in Durg district – based on differences in accessibility to agricultural technologies, agricultural practices and demographic factors (Figure 4.1).

The rationale for selecting Pendra lies in the fact that this region has been in the news since the launch of the NMB. It is claimed that the quality of the seeds and quantity of oil content are better as compared to the accessions of other region, in fact across the country (Sujatha et al. 2013). Indeed, there have been attempts of biopiracy to get

jatropha's germplasm by the foreign oil companies[12]. Nonetheless, we selected this site on the basis that this region fulfils more than 50 per cent of feedstock demand of the Chhattisgarh Biofuel Development Authority's (CBDA) biodiesel refineries (source: Field Study). Cultivation and care of jatropha has been part of their agricultural practices. In this region, people identify the plant with the name *Bhakhranda*, instead of *Ratanjyot*[13] or jatropha – the state-sponsored names, and it has been in use for various purposes by the locals, such as for medicine, as a fuel in burning lamp in place of kerosene, hedge, etc. though the scale of the cultivation has increased enormously after the introduction of the NMB.

Figure 4.1: Field Sites in Chhattisgarh (Pendra and Godhi)

[12] https://www.downtoearth.org.in/news/biopiracy-7357

[13] Jatropha is being publicised by the government agencies and the NGOs as *Ratanjyot* where Hindi is the official language of the state.

In contrast to Pendra, the selection of another field site in the state, village Godhi, is based on its proximity with the industrial belt of the state and different agricultural practices as compared to Pendra. On the one hand, availability of underground and canal irrigation and accessibility to market for agricultural commodities; on the other, the proximity with industries like Bhilai Steel Plant, sponge and iron subsidiaries, and a few cement factories make this region distinguishable from Pendra. The CBDA introduced large scale jatropha plantation in this region and it is still expanding in terms of plantation area and setting up of biofuel refineries.

Madhya Pradesh

Madhya Pradesh is one of the leading states in implementing renewable energy development programmes such as solar, wind and bioenergy. *Madhya Pradesh Urja Vikas Nigam* (Madhya Pradesh Energy Development Council) is the nodal agency entrusted with the cultivation of jatropha in coordination with the State Agriculture Department, the Forest Department and the Rural Development Department. The *Madhya Pradesh Urja Vikas Nigam* in coordination with the other departments involves in the development of nurseries for jatropha plantation, and linking employment generation programmes with jatropha plantation. In this state fieldwork was carried out in Jabalpur (Figure 4.2). The Jawaharlal Nehru Agricultural University (JNAU) is located at Jabalpur and the 'Centre of Excellence in Biofuels' was established as a multidisciplinary research facility in June 2006 at JNAU. This centre was funded to carry out research on jatropha and develop the right genotype for cultivation. In Jabalpur, the researchers from the Centre of Excellence in Biofuels played a key role in promoting the cultivation of jatropha in the state.

The presence of a state renewable energy council, nodal agency and centre of excellence in biofuels was the main reason for selecting Madhya Pradesh as one of the states to conduct fieldwork to map the role of a *research-led* network in promoting the biofuel policies and mission. The researchers at the JNAU's centre of excellence in biofuels have developed dwarf varieties, non-toxic varieties, and developed grafts and saplings which can yield at annual rate. The centre is also promoting jatropha as one of the options for intercropping under agroforestry programmes. Research-centric approach in developing varieties and the cultivation of jatropha in Madhya Pradesh attracted us to choose the state as one of the field sites.

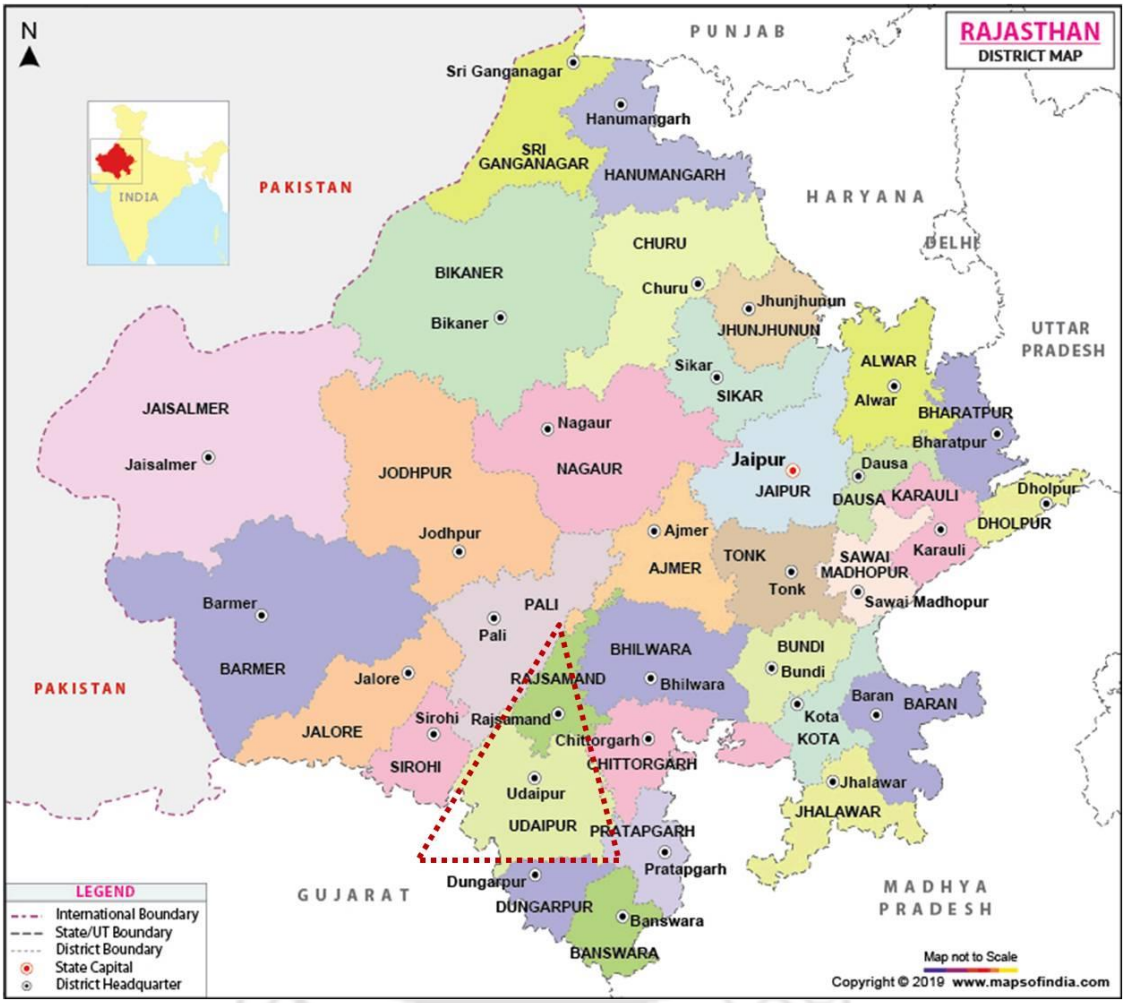
Figure 4.2: Field Site in Madhya Pradesh (Jabalpur)

Rajasthan

In September 2005, the Government of Rajasthan announced a biodiesel mission in tune with the NMB for jatropha plantation through the horticulture programme of the state's Employment Guarantee Scheme (EGS). Subsequently, in the year 2007 the state government drafted a biofuel policy and constituted a separate body namely the Biofuel Authority of Rajasthan under the administrative control of Rural Development and Panchayati Raj Department of the Government of Rajasthan. The state government aims to develop jatropha specific cultivation practices and promote the cultivation of jatropha in 12 districts of the state, namely, Baran, Banswara, Bhilwara, Bundi, Chittorgarh, Dungarpur, Jhalawar, Kota, Rajsamand, Sirohi, Udaipur and Pratapgarh. In this state fieldwork was carried out in Udaipur and Rajsamand (Figure 4.3). In Udaipur and the surrounding regions, many private companies and non-governmental organisations (NGOs) are involved in the promotion and cultivation of jatropha, hence we focus on the *private company and NGO-led* biofuel network in this state. In this region, the fieldwork was carried out in three villages: Devla, Manavto Ka Guda and Gogunda. The main

language spoken in Rajasthan is Rajasthani[14], however, a majority of the people speak Hindi and hence we conducted the interviews in Hindi. In Udaipur, numerous NGOs were promoting jatropha cultivation across the state and they have ties with private companies and the Maharana Pratap University of Agriculture and Technology, Udaipur.

Figure 4.3: Field Sites in Rajasthan (Udaipur and Rajsamand)



On the one hand, where other state governments followed the recommendations of the Planning Commission of India's report on biofuel (GoI 2003) in the initial phase of biofuel crop plantation, and later on, a few states either have drafted their specific biofuel policy considering the availability of local species and farmers' interest such as Karnataka, Meghalaya, Maharashtra, etc. or have lost the enthusiasm over biofuel in general. On the other hand, the Government of Rajasthan has come up with an articulated

[14] Marwari and Mewari are the prominent dialects of Rajasthani. However, Rajasthani is counted under Hindi category in the census of India.

biofuel policy and has linked the Rajasthan Wasteland Development Board's mandates with the Biofuel Authority of Rajasthan. Moreover, Rajasthan is the first state to acknowledge and implement the National Policy on Biofuels, 2018, and has released the State Biofuels Rules 2019[15], in order to ensure five per cent blending of biodiesel with high speed diesel.

4.2 Users of Technology and Oft-excluded Narratives

In the previous section we have introduced the sites of data collection for the present study especially to capture the responses of the farming community, NGOs and agriculture extension officials engaged in jatropha promotion and cultivation. In this section we move on to discuss their responses on why they started jatropha cultivation. What are / were the promotional narratives presented to them from the officials of various government departments, industries, NGOs or the scientists? And, what are the responses of the users of technology in the backgorund of jatropha promotion? By the users of technology, we do not indicate the end-user of biofuel, the consumer of end product. Rather, we imply the farming community as the user of technology not the producers owing to the reason that biofuel technological package as a development initiative was presented to them by the NMB. We argue that these users of technology are not passive recipients of biofuel technology, they are active agents and consumers of technology whose interaction with technology does shape the trajectory of technology. These two spheres, users and technology, are co-constructed (Pinch and Bijker 1989).

The jatropha value chain consists of various activities which can be broadly classified into four categories – farm production of seeds, marketing of seeds, biodiesel production, and biodiesel distribution. The biodiesel production value chain encompasses a wide range of users comprising scientists, bureaucrats, private companies, farmers, NGO personnel, researchers, landless labourers, government agencies and other users. Here the discussion is on the rural users, farmers and landless labourers, and their role in agreeing to cultivate jatropha and its associated farming practices. In the field sites two classes of users are identified: farmers comprising small/marginal, semi-medium, medium, and large land owners, and the labourers, who worked on land owned by somebody else. The users across the sites exhibit different cultural practices and usage

[15] http://biofuel.rajasthan.gov.in/about.aspx

patterns. The farmers have the choice to decide on what to grow on their land, while the landless labourers do or do not have a choice depending on the field sites. Most of the farmers interviewed across the field sites are marginal farmers owning less than one hectare of land.

After introducing the users of technology, now let us move on to the biofuel narratives at the national and village levels. We attempt to identify characteristics of local narratives and how they draw from broader biofuel discourse. Biofuels and especially from jatropha gained attention and popularity owing to the reason that it was promoted by scientific and political elites. For example, Dr. A.P.J. Abdul Kalam in his presidential address mentions:

> We have nearly sixty million hectares of wasteland, of which thirty million hectares are available for energy plantations like jatropha. Once grown, the crop has a life of fifty years. Each acre will produce about two tonnes of biodiesel at about Rs. 20 per litre. Biodiesel is carbon neutral and many valuable by-products flow from this industry...India has a potential to produce nearly sixty million tonnes of bio-fuel annually, thus making a significant and important contribution to the goal of Energy Independence...What is needed is a full economic chain from farming, harvesting, extraction to esterification, blending and marketing. Apart from employment generation, bio-fuel has a significant potential to lead our country towards energy independence...By the year 2030, India should achieve energy independence ... and enhance the bio-fuel production through large scale energy plantations like jatropha.
>
> (Kalam 2005)

Similarly, one of the scientists from ICAR-sponsored Directorate of Oilseed Research, Hyderabad, quotes Mr. Narendra Modi, the Prime Minister of India on the promotion of renewable energy:

> Now the Prime Minister has come up with *Mera Gaon Mera Gaurav* [my village my pride]. Here we can see and expect where such crops can fit in. So rather than thinking of biofuels for country as a whole, decentralised system and reducing the consumption of fuels also. Dialogues should be there between different stakeholders. We also should not take the US approach like growing grass for the fuel, but whatever resources are here, what are the existing systems available, tapping of renewable energy can be a good alternative. We have so much land available where we can go for biofuels.

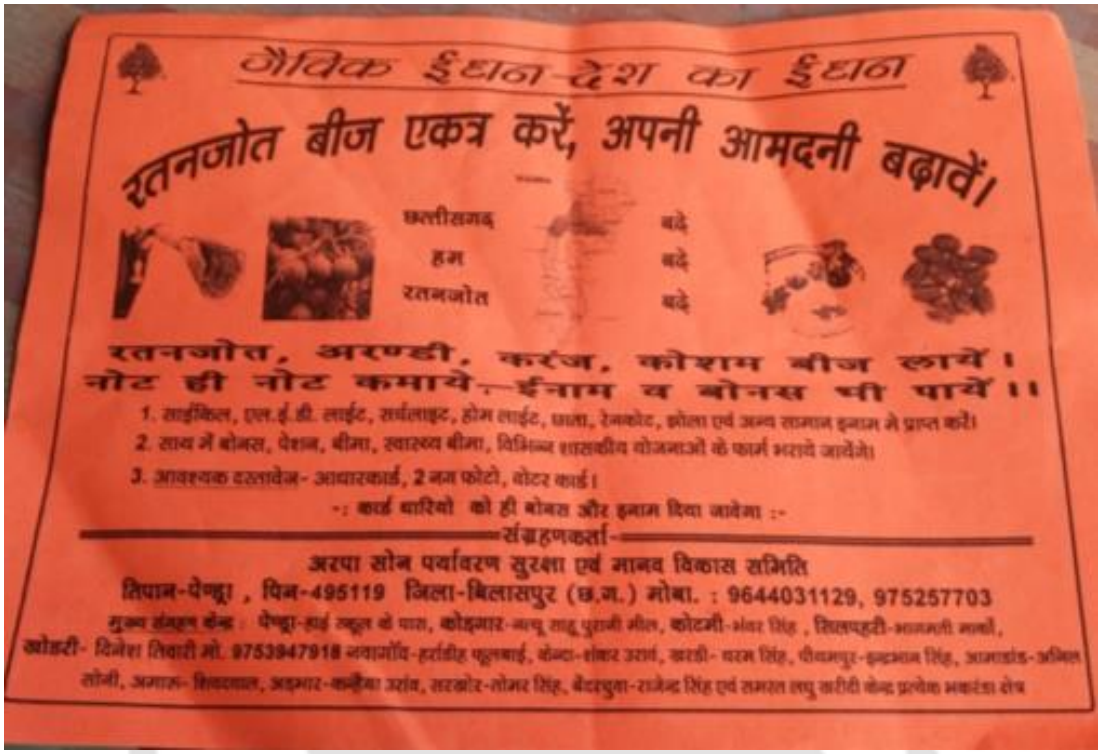
The political and scientific elites have power to reshape policy discourse as argued by Roberts and King (1991, cf. Fischer and Forester 1993). Such discourse presents an imagined future which is possible and attainable through technoscience projects and have the potential to address social necessities. In addition to the promotion of biofuels at the national level, the Chief Minister of various states also promoted biofuels in their states. The then Chief Minister of Chhattisgarh, Mr. Raman Singh, started using biofuel in his official vehicle to popularise biofuel in Chhattisgarh. Perhaps this may be the reason of large expansion of biofuel projects in the state. Indeed, Mr. Singh aimed to achieve 10 per cent mandatory blending in diesel and petrol within 10 years by 2015 after the establishment of the Chhattisgarh Biofuel Development Authority in 2005[16].

On the one hand promotional narratives at the national and state levels are popularising jatropha by embedding it in larger imaginaries of development such as energy independence and rural development, on the other local actors emphasise on micro factors which can attract local people for the advancement of jatropha cultivation. These micro factors influence choices of local people which are related to their daily life or are imposed on them from the state. For example, an NGO is promoting collection of the seeds from forests, bunds and fences in lieu of providing its assistance in accessing various government schemes and programmes. Figure 4.4 represents one of the cases of such promotion in rural areas. An advertising pamphlet of jatropha promotion is presented in Figure 4.4.

The pamphlet starts with promoting biofuel as the fuel of the nation. It links the biofuel production with increment in income, and goes on to imagine the development of the state (Chhattisgarh) and the people with the development of *Ratanjyot* (jatropha). With these imaginaries of the nation and the state's development it includes a few commodities supportive in daily life. Keeping the requirement of local needs, perhaps in the absence or scarcity of electricity and transport, it offers bicycle, light emitting diode devices, umbrella, raincoat, so on and so forth. Moreover, promotion of jatropha is also linked to the assistance in accessioning various government schemes such as life insurance, pension, financial loan, etc.

[16] Source: Field Study. In an interview with the Chief Executing Officer of the Chhattisgarh Biofuel Development Authority, Raipur.

Figure 4.4: Pamphlet of Jatropha Promotion



Source: Field Study

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In some other instances, during our interaction with the farming community across the three states we were informed that jatropha's saplings were distributed with solar lamps, and torch. According to one of the participants from village Mangeli, Madhya Pradesh:

> Before the jatropha plantation the official briefed the villagers that the plant is form outside (foreign county), it will perform well. They also distributed

> solar lamps. The sarpanch[17] allowed the plantation, he said in the panchayat meeting that the in the common land we should plant jatropha. It is for good purpose.

One of the farmers from Devla village, Rajasthan, says:

> Government officers, scientists and NGOs came to our village. They told us about jatropha. They told us that jatropha seeds are very beneficial, it can grow in dry land and with little water. The yield is very good even in less water and care.

Based on the participants being interviewed there is a difference of opinion on jatropha and farming practices, which we will discuss in later sections. However, participants across the states said the similar thing when they were asked, why were they cultivating jatropha? Their response was that their land had lost its fertility and crop yield had reduced over the years. Many of the farmers were in debt or were not earning enough to sustain their families.

The participants said that they primarily heard about jatropha from the officials who came in their cars, these city people representing the government agencies, NGOs or private companies said that our problems would be solved and we could earn money. The same story was repeated across the three states. However, cultures and practices varied across the sites and had an effect on how each set of farmers adopted jatropha plantation. For example, distribution of plants is one of the promotional practices during an election campaign to attract voters and gain their favour. In Figure 4.5 we can observe that jatropha saplings are being distributed along with other plants by the Department of Forest, Chhattisgarh.

[17] Sarpanch is the head of the village / Gram Sabha. Gram Sabha is a village level constitutional body assigned by the 73rd and 74th amendment in the Constitution on India. Source:https://www.pbrdp.gov.in/documents/6205745/98348119/Panchayati%20Raj%20System%20in%20Independent%20India.pdf

Figure 4.5: Distribution of Jatropha Saplings with Other Plants

Source: Field Study

In another example from Rajasthan where we identify the *private company-NGO led* biofuel network. On interaction with an NGO representative engaged in promotion and collection of jatropha seeds in Udaipur, Rajasthan, we notice that a specially designed bag is distributed by the NGO in nearby villages of Udaipur and Rajsamand districts to collect jatropha seeds. In the words of the NGO representative:

> We are involved in promotion of jatropha. Whenever I visit to other places or other states, I meet the people who are engaged with jatropha. I listen to them, about the local seeds and tell about our region's. At local level I distribute pamphlets to spread more awareness about jatropha seeds. We have also designed and distributed a seed collection bag which is in two sizes: one's capacity is seven kg and another is of fifteen kg capacity. So that a person of different age can use according to his/her capacity while collecting the seeds. In this way we keep bringing new ideas and things for jatropha. This is a small effort to bring faith among the villagers. Such small-small thing establish faith, and other small things are also the reason of breaking the faith.

The analysis of the local narratives supporting the production of biofuels in India advances Keeley and Scoones's (2003: 68) claim that while global narratives do influence local narratives, local narratives have unique characteristics of their own that "reflect local knowledge, local interests and local complexity". Reflection of such characteristic of the local narratives for the promotion of biofuel can be seen in the slogan coined by Mr. Raman Singh (the then Chief Minister of Chhattisgarh) during a demonstration of a biodiesel processing unit in Raipur, "*Diesel nahin ab khadi se, diesel milega ab badi se*" (No more diesel from the Gulf, we will generate it in our farms).

4.3 The Process of Land Diversification for Jatropha Plantation

When a new programme or proposal is initiated by the government, panchayat is called upon to discuss the programme. At the outset, elected panchayat representatives (*panch*) discuss the programme. For example, a proposal to construct a bridge, pond, or small dam, is being discussed among the representatives and gets passed by them at the very first level. According to the Sarpanch of Godhi village, "*each and every issue cannot be discussed by the Gram Sabha. Calling the meeting of the Gram Sabha is cumbersome and time taking*." There is an elected representative from each ward. If the proposal has consent of majority then it is considered passed. Suppose, there is a proposal to start a small industry in a village. The proprietor would apply for the permission of village through panchayat, then it will be discussed in the Gram Sabha. Usually the meeting of the Gram Sabha is headed by the Sarpanch, if s/he is not available that day, another person of good repute is being elected to head the session. This session is observed by an officer in the rank of BDO (Block Development Officer). In the meeting of the Gram Sabha two-third majority is required, unlike the meeting of the panch where normal majority is sufficed to pass a proposal. In the following discussion we attempt to compare the responses of the farming community on initiation of jatropha plantation and other industrial projects vis-à-vis negotiations held in the Gram Sabha. And, in turn we discuss how land is diversified through such 'development' projects and thereby acquired by the government and private agencies.

The Sarpanch of Godhi village compares the situations when a proposal has general dissent and assent of the people:

> In the case of sponge iron factory, dissent will arise, because, definitely it is going to harm water, soil, air of the village. In case of brick kilns or settings for bricks from fly-ash, as such small-scale industry, usually the villagers have on objection. In this case who will object: suppose I have sold my agricultural land to someone, and that person wants to set a brick kiln, then he has to divert this land as a *parti zameen* (infertile land) from the administration. After permission from the administration one can start the small industry. In the case of *ratanjyot* (jatropha) plantation, the situation is somewhat different. Initially the land was given to the forest department. Villagers did not object the plantation as it is not going to pollute air and water of the village.

Aalok, one of the participants from Mangeli village, Rajasthan, expresses the same opinion on the acceptance of jatropha planation in the village:

> They said they will employ locals in the plantation. This was a government scheme, therefore we agreed to give land for this scheme. And, it's our duty to extend our support to schemes offered by *sarkar* (the government). But it also upon us, if we oppose any proposal either coming offered by the government or private, the proposal / scheme would not take the further course. It is mandatory to take the permission from the panchayat and village. but, as such nobody opposed the plantation in our village.

One of the participants, Sunil from Gogunda village, Rajasthan, explains the dynamics of agroforestry, fuelwood and jatropha plantation and thereby the diversification of land:

> A few years ago, the forest department planted Gooseberry, *Mahua* (Maduca Indica), and some other varieties. Facility of irrigation was not there, and the villagers used to cut the trees for fuel needs, these led to decay of the trees. This plantation was dense and a kind of small jungle. Settlements in the village was expanding and simultaneously need for fuelwood. The villagers had no option but to cut trees for fuelwood, and the space became barren. This land was used for ratanjyot plantation. Similarly, in other villages also ratanjyot was planted in land of forest department. And this land earlier used to belong to village common property but the forest department took NOC (No Objection Certificate) for agroforestry programmes.

However, there are a few instances when the farming community has protested against acquiring the NOC and establishing a new industry. Rukmini, one of the participants from Godhi Village, Chhattisgarh, narrates an incidence when a request for NOC was furiously opposed by the villagers:

> Many companies came for the NOC, but we did not give. Our policy was that you can take the land for agricultural purpose not for industry. We have given our consent for NOC to open a seed factory, but for beer factory we said no. The owner of beer factory, who has close linkages with the Chief Minister of our state. We knew that around fifty to fifty lakhs of rupees have been given to acquire the NOC. But the people movement forced them all to shut down the project, even though the stake of big shots were involved in it, but our people did not afraid. That movement continued for eight days and night in front of the Sarpanch's home.

Similarly, Deepak from the same village brings up the example of a cement factory. However, the NOC was approved by the Gram Sabha, but later on there are some conflicts over the employment and subsequently the locals feel betrayed by the cement factory:

> Now how the problem arises: the NOC is issued for five years by the Panchayat by taking the consent of the Gram Sabha, and after each five years the NOC has to be renewed. Panchayat levies tax for the NOC. So, after the first five years the tiles and marble company neither paid the tax nor seeking for the renewal of the NOC. This has become the reason for frequent clashes and arsons among the villagers and the factory administration. We do not want to revoke the NOC, but these factories are big and have linkage with politicians and the government, we cannot do this.

Although the biofuel projects were not protested by the farming community initially, Vivek, one of the participants from Godhi village, Chhattisgarh, elaborates:

> When they [CBDA] was planning for the plantain in this village, they asked for the NOC from the panchayat. Nobody objected for giving the NOC because the purpose was just planting some trees, and it was the government land and earlier plantation drives were also there for gooseberry, mango plants, etc. so nobody objected. Before the jatropha plantation the official pursued the villagers that the plantation will bring prosperity in the village, people will get employment, and it does not require two much efforts also. The sarpanch allowed the plantation, he said in the panchayat meeting that the land belongs to the government, and we should give the NOC for the plantation. Now CBDA is expanding here, they are proposing a biodiesel plant in the vicinity of the plantation. I think they are increasing the plantation area, and also planning to set a plant for biodiesel.

On a similar note another participant from the same village expresses his agreement on jatropha plantation, though he has some apprehension over the response of the villagers:

> In the case of jatropha plantation there was no protest, because it is a government project and it is for the environmental conservation. Now there

is a proposal to set a biofuel expeller plant beside the plantation. The NOC has not been requested by CBDA people yet. I do not know what would be the fate of this biofuel plant by looking at the attitude of the village. But these small projects would not benefit many people, factories like Bhilai Steel Plant is required where more and more people can their livelihood.

Agroforestry programmes both in India and across the developing nations have reduced the stretch of common property land due to elite captures (Agrawal 1986; Jodha 2000). Along this line, Borras et al. (2011) bring our attention to land acquisition and land grabbing related to biofuel expansion. The biofuels policies and programmes, and 'wasteland development' initiatives in general as discussed in the Chapter II, have failed to acknowledge the social dimension of common property land. During our field study we encountered a similar instance where a considerable area of land has been acquired by the CBDA for jatropha plantation and access of this land has been prohibited (Figure 4.5).

Figure 4.5: Land Acquisition for Jatropha Plantation

Source: Field Study

This land used to be considered a common property of the village, now it is inaccessible. We observe from the above responses that the village communities can use their constitutional rights by denying the NOC requested by private or government agencies,

however it seems, the rights seldom have been exercised in the context of jatropha plantation.

In this section, we observe that the common property land of a village is being diverted either to the government agencies or private industries. Further, tree planting schemes on the commons often failed to mature because it was unclear how benefits would be shared (Saigal 2011). In our case also the locals used the plantation for fuelwood. In addition to this we observe jatropha plantation is promoted with the assurance that it would arrest land degradation and contribute to India's environmental and rural development goals by 'greening' marginal lands and providing jobs and new market opportunities to the rural poor.

4.4 Modes of Jatropha Cultivation

During the field study, the most commonly observed model is the farmer centric one, where the farmers own land and they are provided with seeds at reduced costs from the government. The farmers cultivate jatropha and can sell their harvest to whoever they want. An overview of the farmer centric mode can be captured from an interaction with Arun, one of the participants from Devla village, Rajasthan:

> Jatropha plantation was started in our village by an NGO and the forest department. They were planting along the roads and nobody from the village opposed it. I was also in support of plantation; indeed, I showed the villagers how to plant and care *ratanjyot* plants. Water body was not there for the irrigation, so I managed to set a borewell for the irrigation. I did many things from my side. Similarly, so many people from our and neighbouring villages started jatropha in their field. But, all of them do not have borewell, so their seed quality is low and not as much as compared to mine.

The second mode involves plantations on government land managed by the rural communities. The government land classified as wastelands encompasses common property resources, the land which is used by communities for cultivation of crops, and grazing of livestock. In the second mode the government land is managed by the joint forest management committees or other government agencies along with Self Help Groups (SHGs). The various government agencies like the state biofuels boards, forest departments, the National Oilseeds and Vegetable Oils Development Board (NOVOD), etc. are key players in this mode. They have to ensure that the farmers are provided free

seedlings, trained on pruning and plant maintenance, fertilisers and manure, and informed about buyback mechanisms. Though in this mode of the plantation so many agencies are involved, it receives a few critical notes from the locals. According to Meshram, who runs a snack shop at Devla bus stand, Rajasthan:

> Maintenance of the plantation is required throughout the year. The forest department just planted and left it without proper care. The seeds are poisonous also, you must have read in the newspaper about the incidences that children had to hospitalized after consumption of the seeds. The forest department needs to do some fencing to avoid such incidences; or at least one guard should be appointed by the department (*kam se dam ek chaukidaar to ho*), so that nobody could harm the plantation or could harm themselves. What they have done, they have just dug around the plantation to restrict the entry of cattle / herds. Through this measure you can limit cattle not humans. It is kind of isolated place on the other side of the village, now this place has become a picnic spot for some, people come from the outside, they drink and leave the place dirty, even couples have started coming to take the advantage of this isolation.

Sanjay, one of the participants from Godhi village, Chhattisgarh and the caretaker of the CBDA jatropha planation, talks about the labour requirement in government led plantation:

> At least ten permanent workers on full time basis are required to maintain this plantation. When pruning is scheduled more than fifty workers will be needed. Around 26,000 plants are here, and for pruning all branches should be cut, so with ten workers it is impossible to finish the work in limited fixed time. When the plantation was carrying on in the village around fifty labourers were involved from the village.

Nonetheless, on different a note, in this mode the farmers are either landless farmers, or landless labourers who are hired to work on the land. The majority of the labourers are placed under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) which guarantees hundred days of wage-employment to rural household members. Many NGOs and SHGs are also involved in this mode. Here the harvest belongs to the government agencies.

The third mode followes a different approach, it is the corporate mode of cultivation. It is business oriented as it is managed by private firms both local and international. In this mode the companies either buy or lease vast tracts of land and employ farmers or

labourers to plant jatropha, or they form contracts with the farmers or local communities to grow jatropha on their own land. In the contract farming mode, the company provides the farmers with cheap seeds or loans and they promise to buy back the seeds at a fixed price. The proportion or majority of mode followed, varies across the field sites based on the nature of rural users and practices. However, the village communities express their concerns over contract farming. A majority of them opine that these private companies come up with promises of employment but later, once their setup is ready, they have to face betrayal. In the words of Urmila Sahu, ex-sarpanch of Godhi village, Chhattisgarh:

> Some say that these companies will employ local people, when they asked for land. Once they got the lease or manage to buy our land, they ignore us and the promises they made during the land purchase. They employ *Bihari*, *Punjabi*, *Odiya* [sic][18], people from other states but not us. They behave like big brother (*ab daau ban gau hai*). In initial stage of the plantation, they start with local contractor to supply the labours, and after sometime when the contract got over our people lose the job. It is a pattern, which every company repeats here. It is not specific to jatropha plantation only. JK Laxmi cement also did the same thing.

Sandeep, one of the participants from Pendra, Chhattisgarh, narrates his experience with private companies:

> After this other companies also came like Reliance and Emami. The entire India was rushing towards Pendra. Big business houses of India's other states as well as of Chhattisgarh were very keen in jatropha. They thought let's go to Pendra and make fool people out here. They purchased the seeds in very low rate and resold in very high prices. They also sold the plants which should not be done. They made money and went aside. They betrayed to the locals.

It is not the case that the village communities observe not-so-optimistic experience with private companies only. In other instances, other public sector companies such the Hindustan Petroleum Corporation Limited (HPCL) and Indian Oil Corporation Limited (IOCL) collaborated with the state biofuel authorities and in some cases opted for contract farming with the farming community. The companies were engaged in new jatropha plantation, maintaining the existing plantation, and, proper application of water

[18] Though, we understand that these impositions of such identities are racial and rationalistic in nature. We do not intend to use those, we are just quoting what our respondents express.

and fertilisers. These were the targets to public sector oil companies set up by the Government of India to develop a biofuel market. However, it is reported in the field sites that these public sector companies could not maintain the plantation and discontinued the contract with both state biofuel authorities and with the farming community. According to one of the participants from the CBDA, Raipur:

> They had contract with CBDA. CBDA agreed to give them fourteen rupees per plant per year. Which is too much rate for a plant. Around lakhs of hectares area is under jatropha plantation in Chhattisgarh, and one fourth of it lies here in Pendra-Marwahi belt. These companies did not have any goal or vision for the plantation. They were here for around three-four years, after making crores of rupees, they left. The MoU between CBDA and the company (in collaboration with HPCL and IOCL) was that they have to supply the seeds to the CBDA because the CBDA is providing free land and cost of the maintenance. They barely could provide twenty tonnes in three years. They did not make full payments of the wages to labourers who were engaged in the maintenance.

4.5 Nature of Engagement with the Plantation

The NMB and the NPB were promoted as rural development programmes which would seek to address some of the issues affecting the agrarian sector (GoI 2003). The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) is a key poverty alleviation and employment creation initiative of the Government of India. The aims of the programme are: to provide employment to the villagers, stabilise agricultural production and reduce migration from rural to urban areas, to ensure that there are fewer deaths from starvation, to strengthen the livelihood resource base, and to boost the rural economy and enhance the capacity of the villages to sustain themselves.

The policymakers and government officials claim that the cultivation of jatropha would fit the objectives of land development, creation of employment, and durable assets under the MGNREGA. It claims to provide labour opportunities for the landless and if they are enrolled under the MGNREGA scheme they will receive wages for their labour irrespective of the output, in this way they do not have to undertake contract farming, and they do not have to invest any money. Based on the guidelines of the MGNREGA many states including Chhattisgarh, Madhya Pradesh and Rajasthan, actively invested in jatropha plantation and received funds from the central government. However, against these claims of linking the NMB with the MGNREGA, an overall picture in one of the

field sites displays contrasting picture of the employment situation. According to Shubham, a landless labourer from Godhi Village, Chhattisgarh:

> Initially people opposed the plantation. A group of villagers started lobbying against the project, on the ground that the factory will invite people from outside, hooliganism will start, and it would be difficult for the women to go to fields for daily necessities, surrounding of the village would get disturbed. This group started brain washing of other villagers. If it would have been established in the village, unemployed youth of the village would have got some livelihood, they did not have to go outside for livelihood.

The participant goes on to express his concerns over the employment situation of the village:

> Here the number of people is more those who do not understand. At least 200-300 people would have got some job by those projects, and unemployment would have vanished from our village, but people could not understand this. Now they are thinking and regretting. The youth of village is jobless, now the protesters are realising. Their children are roaming here and there for search of job. There is no source of income other than agriculture. We have to go to Bhilai, Raipur, Kumhari, Durg for job. There we are getting Rs.170-200 on daily basis, petrol takes fifty, and eatables around 30-40 rupees. We are able to save less than 100 rupees from this. You think, how we are managing our family in 100 rupees? If here in village 200 hundred people are engaged in some job, at least they would be better position to take care of their family. People from other villages like Dhamdha, Khairagarh, Gandai, they migrate to big cities for seeking job. But from our villages people do not go that far for job, unless they are not employed in some government job.

The biofuel development narrative along with targeting the creation of employment also emphasises reviving the agricultural sector. Among the solutions which have been proposed, the diversification of mixed cropping with jatropha or only jatropha plantations on wastelands has been one of them. Jatropha plantations under the MGNREGA has been claimed to be conducive because the gestation period of the plant is from three to five years and requires pruning at intermittent time intervals. Additionally, labour can be employed to pluck the oilseeds once they are ready to be harvested.

An additional narrative underlying the biofuel missions and policies are that the production of biofuels would attract investment by a range of private companies and their interest in the biofuel sector would involve the association of NGOs and confer livelihood

benefits to small-scale farmers (GoI 2003). The proclamation of interest in biofuels attracted a multitude of companies both local and international to invest in the biofuel industry. On the one hand, many of the interviewees especially government officials opine the presence of these companies is good as they will invest in the nascent biofuel industry and encourage the production of biofuels. As many of the companies did not own large tracts of land they would encourage small-scale farmers to plant jatropha. Companies like D1 Oils, Mission Biofuels, Emami, Reliance Ltd. did indeed invest actively. On the other, the village communities have differing opinions on the role of private companies. Mukesh, one of the participants from Pendra who teaches in a nearby government primary school, explains:

> There is…another reason, the villagers want job assurance in written from any company that they would employ the locals. But why would the companies do that. Here the locals do not want to work more, if they have earned hundred rupees today, they would not go for work tomorrow. On the other hand, outside labourers do work for twelve hours per day and they take minimal leave, because they know, they are here for the work only. Local people want eight working hours, an off in a week and two hours of lunch break, with such demands how an industry would survive? Take the example of rice mills of the neighbouring village. There are incidences of trade union politics, arsons and curfew. At that time, it was a big story in this area. The manager's argument is that the company has paid the amount of the land to the landowner, and there was no any such of contract that the company has to give job to the locals. The company requires skilled labour, and the locals are not fulfilling the criteria for work. And in this situation, we, the people of neighbouring village do not pressurise the companies, because these companies are private, they have ownership over it, the owners are free to take their decision. They have bought land for the factory and it is their wish, capacity and requirement, accordingly they recruit the locals.

According to many interviewees these companies follow a strategy referred to as 'the closed loop mechanism'. According to this the companies entered into a contractual farming agreement with the farmers and procured feedstock from the farmers and set up processing facilities in the vicinity of the feedstock sources in order to process raw materials. The private companies involved small-scale farmers by agreeing on contract farming and it was considered that it was a "win-win" situation for the company and the farmers. Many small-scale farmers could also invest in mixed cropping on their fertile lands. From the NMB and the NPB it is evident that if the biodiesel blending standards are implemented across the country there would be a steady demand for jatropha seeds

and new plantations. Hence small-scale farmers who grow leguminous crops can also grow jatropha on their land and while they are getting returns from their staple crop they can get extra income from harvesting jatropha seeds.

D1-Mohan Bio Oils Ltd. has developed a farming contract (through mediation by Apra Son NGO) with farmers in Chhattisgarh to cultivate jatropha. According to the contract, farmers are provided with free jatropha saplings to grow on their land and during the period of the contract, the company officials provide technical advice and guidance to the farmers. A rate of Rs.7-10/kg was set to be paid to the farmers based on a buy-back agreement, and the main conditions are that the company would definitely buy the produce, while the farmer has to sell to them and also repay part of the loan with the harvest. During the period of the contract the company agrees to give a loan amount of approximately Rs.15000 per hectare over two instalments, around two-thirds of the sanctioned amount would be released in the first year and the rest would be given over a period of two years.

The main role of D1 Oils is to provide finances for the contract while the role of Mohan Breweries is to convince the people to enter the agreement and ensure they deliver the final product. Local staffs are entrusted with the task of informing the farmers about the biofuel policy, jatropha, and benefits of cultivating it. The farmers and labourers interviewed say that officials from the company regularly visit the villages where jatropha was being cultivated by farmers who have contracts with them. Their visits are to check on the plantations and also to persuade more farmers to form contracts with them. Narottam Sone, a farmer from Pendra, Chhattisgarh, who was initially reluctant to grow jatropha, says "*these officials were local educated people whom we knew and they were very persuasive. I thought if they are saying and so many people are already growing jatropha perhaps even I can do the same*". However, another respondent from the same locality mentions the jatropha surge and deviant practices adopted by a few companies to increase the profit:

> In 2008, when jatropha was in boom, it also came here in our small town, though it was already here but not in this large scale. So many foreign companies used to visit this place, our chief minister also paid a visit. These news were widely covered in local and national newspapers. One news was also there which claimed that according

> to the Defence Research and Development Organisation quality of Jatropha of this region is best in entire India. So, the demand of the seeds and plants went very high, therefore the prices were also touching the height. Then some private companies started unethical business practices. I believe that whatever the good things are there in the world, some people first try to destroy it, after that they start making money out of it. A few companies and the scientists associated with them took advantage of it. The cost of one cutting would be one rupee, but they started selling the cuttings to others at rate of ten-twelve rupees. They did jatropha plantation in some spots, made crores of rupees from it and left the place.

4.6 Implications of Jatropha Cultivation for the Farming Community

The plantations are carried out on land identified by the state governments of Chhattisgarh, Rajasthan and Madhya Pradesh as wasteland. However, the people living in these villages claim that "*it was their land and they had been using it for years and all of a sudden the government decided to use the land for something else*". The villagers are told by officials from the CBDA that they do not have to irrigate the plant, all they have to do is to harvest the seeds after three years. According to the rural users, the prospect of earning money from the harvesting process reassured the villagers to an extent and despite their dissatisfaction with the new initiative they did not protest too much. Within a year the vegetative growth of the jatropha plant was very high and the plant grew very tall. They were impressed and thought it would flower even before three years. They thought they would be rewarded by the government officials. However, when the officials returned a year later they were dismayed to see the rate at which the plant had grown. One of the participants Jageshwar Pottam from village Godhi, Chhattisgarh, says what the officials told them:

> They asked us why we had not cut the side branches. We told them we did not know we had to prune the plant. They said the plant had grown too high and had not been pruned at the right time. Now it would not yield enough seeds. We were told to uproot the plant and sow new jatropha seeds.

The villagers were not been informed about the importance of pruning and how the failure to do would drastically affect the rate of yield. This can be captured in the words of Sohan, one of the respondents from Pendra, Chhattisgarh:

> The special characteristics of the jatropha variety we have here is that after pruning in summers the cuttings / branches you get, you can plant them without water. This region becomes water scarce in summers. But these

> cutting can survive without water and within a year it attains height of 4-5 feet, and start flowering in next six months. This is the traditional method which is being practiced since centuries. I am not a scientist, I am telling you what I have been observing and what is being practiced here.

On the importance of pruning for plant survival against the virus attack, one of the scientists from CSIR-sponsored National Botanical Research Institute, Lucknow, suggests:

> Though jatropha is more susceptible to virus attack in the sense if you can manage/control the virus coming in contact with the plantation, but if once virus attack is there you cannot do anything. Interestingly viruses do not attack directly means they come through some secondary sources e.g. insects. If one can stop insect contact viruses can be controlled easily. There are methods of virus control: first of all, pruning should be at proper time, water should not be stagnant in plantation area, all the things which attract to come over there. If pruning is done in the beginning of dry season virus attack can be checked, but if somebody thinks in the beginning of rainy season pruning will result for better sprouts, the one should also consider it will attract insects as well.

The scientists, state officials and members from the CBDA did not anticipate the knowledge gap of the rural farmers and labourers with regard to jatropha and related farming practices. Despite this failure, the villagers were not paid for their services of planting jatropha and were in turn coerced to plant jatropha again. Further, the knowledge gap is not limited to pruning only, it stretches to the method of the plantation, water, fertiliser requirement, etc. Here we take a few instances of the method of jatropha cultivation and then attempt to juxtapose the views of the scientific community with the experiences of the farming community. For example, one of the scientists from CSIR-sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar, explains the difference between the use of plant cutting and seedling for cultivation:

> We do not want which is giving vegetative growth. We want some balanced plant which can give some vegetative growth and more of reproductive seeds. We have developed some techniques, where vegetative growth diminished and the same time seed yield got increased. One should always plant cuttings not the seedlings, because seedlings have genetic variability. If you plant thousand plant, all will behave differently. Whereas, if you take cuttings or tissue culture plat, the yield will be consistent. And other important point is cuttings and tissue culture plant should be from known varieties or from known plant of good history. We did like that, we have plantation at Odisha

> since very long time. Here we kept on selecting the varieties. We finalised on two varieties from which we generated further cuttings.

There is a plurality in the epistemic practices adopted by the various scientists, the private companies, and the state biofuels development boards. As from the above response we can observe that the respondent is in favour of plant cutting for the cultivation. In other cases, we have come across the examples where seedlings were distributed by the state agencies and private companies for the plantation. Similarly, there are differences on the use of hybrid and genetically modified varieties for the plantation. According to one of the scientists from the University of Delhi:

> I do not have interest on genetically modified (GM) plants. I go with traditional breeding. Science has some limitations. For some disease testing tools are available and for some not, if you introduce new gene, definitely it will work according to its function, but it also changes some function of organs of plant, which cannot be detected at the moment and cause some problem in the future. In GM plants we observe jumping genes, means they do not have uniform behaviour.

Another scientist from ICAR-sponsored Central Research Institute for Dryland Agriculture, Hyderabad, points out the role of public and private research institutions on the development of hybrid seeds:

> As far as private companies are concerned they are developing only hybrids. Every year they are developing and selling. They have resources and facilities. They can invest every year and develop a hybrid and sell it to farmers. In case of public research institutions, they cannot invest in hybrids therefore they are focusing on development of varieties. The private research institutions are making changes at molecular level, tested with DNA finger printing. With this at seeding stage testing of characteristics can be performed, it reduces the time, otherwise we have to wait for four to five years.

The private companies focus on the development of hybrid which requires less resources and time. In addition to this, hybrid varieties can be used once owing to proprietary constraints imposed by the private companies (Kloppenberg Jr. 2005; Carolan 2012). However, one of the scientists from ICAR-sponsored National Bureau of Plant Genetics, Hyderabad, explains about the importance of variety development vis-à-vis limitations of hybrid seeds:

> Research and development is required in area of variety development for jatropha, because hybrids are limited to one generation only. Varieties are developed after monitoring generation after generation and that may take eight to ten years to develop a variety. Repeatedly you have to monitor, you have to self-cross the flower to retain the same character for that generation. Selfing is required for the initial generation, so that purity can be maintained. And then after years of work you can get the desired characters in a variety. So, to develop a variety it takes lot of time, for perennial crops the period is eight to ten years.

From the above response, we can observe that the variety development of a plant requires more time and thereby more resources in comparison to hybrid seeds. The prevalence of hybrid seeds for staple crops starts from the Green Revolution in India. It has changed the agrarian relations in a way that agriculture pursuit has become more market dependent not only for post-harvest commodities but on inputs such as seeds, pesticides, fertilisers, etc. (Gupta 1998). Ritesh, one of the participants from Godhi, Chhattisgarh, shares his experiences on the use of hybrid seeds and prevalent agricultural practices in Godhi:

> Earlier we used to preserve seeds for the coming year cultivation. After the introduction of hybrid seeds, we cannot do this. The seeds can be preserved for next cultivation but these seeds will not give that much production. So, every year we have to buy new seeds. But hybrid seeds give good production and some certainty is also there. These days most of the people prefer hybrid seeds. Those do not have resources and proper income they use ordinary seeds. Harvest from these both varieties of seeds is almost similar. But the hybrids give more production. Now too much chemicals are used in cultivation, so forget about the taste from rice or pulse. The taste from the grain has almost vanished. There is an old person, Yadav, in my village, he still does not use chemical fertilisers. We have become so accustomed of chemical fertilisers that without the use we cannot expect any production. But, Yadav Ji only uses manure prepared at his house backyard. The taste of his field's paddy and ours is quite different. And the colour is also different, produce of the hybrids is whitish, and of Yadav ji's its reddish. But his son is interested in using hybrid seeds and chemical fertilisers. He is not satisfied with the current production from their field. So one day he was enquiring about the amount of hybrid seeds and fertilisers required for his field. Generally, when you are using the preserved seed, it requires around 20 kathha [1 kathha = 3 kilograms] of preserved seeds, on the other hand only 10 kathha of hybrid seeds are sufficient for one acre. And the current price of one sack [one sack = 30 kg] of the hybrid seeds is Rs.1200 from the cooperatives. The quantity of both the types is different because germination rate is different. As the price of hybrid seeds is increasing continuously people have become conscious over the quantity they are purchasing and production they are getting. They have improved their method of cultivation.

> Now they give one by one foot spacing on each plantation. There are various techniques of paddy cultivation, but the important in all the techniques, if you do not do plantation after thirteen days of sprinkled seeds you are not going to get a good harvest, whatever the variety of seeds you are using.

Jatropha is a perennial plant. Its full cycle of crop does not complete within a year. The scientific community suggests that one has to observe its performance year by year until it reaches a stable condition. After four to five years of the plantation it reaches the maturity level and then only yield from the plant gets stabilised. Moreover, factors such as soil characteristics, water, fertilisers, etc. contribute immensely from the period of growth of the plant to the point that it gets stabilised. Dinesh, one of the participants from Pendra, Chhattisgarh, who is engaged in jatropha cultivation for almost twenty years reflects on the recommendation of the scientific community over conducive conditions for the plantation:

> A few scientists came and said jatropha cannot yield in black soil, where I do the soil is black and the plants are flourishing. The scientists said that a plant cannot yield more than hundred grams, but my estimate is 300 to 400 grams if you give little bit attention to the plant and care for it. My encounter with the scientists is that they just follow the opposite direction. They suggest for 1x1x1 or 2x2x2 feet pit for the plant, which should be filled by manure. This is the wrong way of planting jatropha. Actually, the method should be that first do the soil preparation.

He goes on to comment on the importance of soil preparation before and after the plantation:

> These plantations are like our local cows or local guava. People just exploit them, do not feed them properly, and complain about productivity and quality. Similar is with jatropha plants. If you want to get some yield from it, just pay little attention. Even if one is not able to do any thing, just turn the upper soil twice in a year. People even do not bother to put that less effort. One of the characteristics of plants like milk hedge that they soak very less water.

The biofuel promoters portray jatropha as disease resistant and that requires less water. However, the farming community experiences that the deviation on the performance of plant emerges during the plantation. According to Pavan, one of participants from Devla, Rajasthan:

> Along with pruning other things are also required. Like availability of proper sunlight, small plants should be protected not to fall in the shadow of bigger plants, irrigation is required after the month of December, otherwise plants may be prone to termite attack. There is another plantation by the biofuel authority in a nearby village to Devla. That plantation is fragmented in four part: two in fifteen acres each and another two in twelve acres each. So, one of the parts of this plantation was badly affected by termite attack. Caretaker of this plantation could not take care of it because he got fractured his leg in an accident. This plantation is good, but due to lack of proper care and irrigation this plantation is affected by termite attack.

Accessibility to water in general and irrigation in particular has been a contentious issue in rural India. The biofuel missions and policies promote jatropha a sturdy crop which requires less water and subsequently it can be grown in dry and marginal lands. In the above discussion we try to pose the experiences of the farming community with jatropha plantation with reference to soil and water requirements. Mosse (2000) in his study on irrigation system in South India connects the state with community with the link of irrigation. According to him, irrigation provides a unique perspective on the relationship between centralised power, local lordship, and local communities. In the field sites of the present study, especially in Devla and Gogunda, power relations are exercised through irrigation. For example, a canal passes through various villages and connects these villages from water source. However, the availability of water is not certain. According Pramod, one of the participants from Devla, Rajasthan:

> There is partiality in water distribution among the villages. A few villages get water throughout the year. For us, if we get even in cropping cycle when it is most required and during the summer, we thank the authorities. Some villages are so influential that they get water to fill the ponds during the summer. Usual practice is that every village which is connected to the canal system will get water twice in the year. Once in the month of October, nearby Navratri so the crop can be ripened properly, second, in the month of April, the wedding month. In this month guests come from outside, so sufficient water should be there to cater the increased demand of water.

In contrast to the claim of a few scientists and the officials who promoted that the plantation does not require irrigation and its biomass can be used as manure, Sanjay, caretaker of one of the jatropha plantation started by the CBDA, states that he has not observed any beneficial effects of manure prepared from jatropha biomass.:

> In 2003-04 forest department people used to come with small jatropha plants and asked us to plant it in our farms' bunds. They said the plat does not require much water and any addition support like fertiliser or pesticides. But that variety was not very successful. The 2008 plantation is a success. You can see the growth and height of these plants, and seed quality is also very good. In this plantation we have two heavy motor pumps for irrigation. Irrigation facility is there therefore we are able to get good yield twice in the year. Now [November, when the interview was conducted] the flowering has started by December mid you will be able to see the fruits. Before the flowering of the plants pruning is must. After the pruning cuttings are used to prepare manure. The officials claim that the manure prepared in this way is very fertile, though I do not have any experience of this.

One of the scientists from ICAR-sponsored Indian Grassland and Fodder Research Institute, Jhansi, questions some of the laboratory practices and the promotional claims based on those practices:

> The pot experiment is not a scientific practice which is occurring at laboratory. But when it was tried in the field, the yield was very less compared to what was projected through the pot experiment. And yield was also not consistent from the same germplasm. Like, here you can see other claims who understood this inconsistency as part and parcel of certain varieties those produce in alternate years like mangos, one year yield will be moderate and next year nill or very less yield, but in the third year the plant will again produce with the expected one. This is similar with jatropha, you cannot expect consistent yield.

As we have discussed in Chapter III, that the scientific practice is a cultural extension which takes place in a laboratory. In the process of scientific practice, characteristics of an object / material are not know in advance to scientists. The previous response of the scientists acknowledges such unpredictability during an experiment and criticises those practices such as 'pot experiment' that turn out to be a basis for jatropha promotion.

The government and biofuel lobbies have contended that instead of displacing the rural communities this 'wonder crop' can in turn enhance their livelihoods. The government officials say that, jatropha seeds can be sold at a good rate in the market, and with the ensuing steady demand to meet the biodiesel blending targets it can turn out to be a 'gold mine' for the small farmers and landless labourers. To prove their logical claims and support towards this non-edible crop, in many states the government distributed free seeds and encouraged the farmers to plant jatropha. For example, one of the scientists

from ICAR-sponsored National Resource Management Division, New Delhi, reflects upon the readiness of biofuel technology for the farming community:

> Three or four companies are working on biodiesel, and their technology is ready for the farmers. If farmers are interested they can take plants, in cutting or tissue culture form, for the cultivation. Our institute has also developed clonal propagation by both the ways: stem cuttings and tissue culture.

However, one of the scientists from CSIR-sponsored Central Salt and Marine Chemicals Research Institute, Bhavnagar, has a different opinion on the sustainability of jatropha and states that it was promoted without proper research:

> Actually, what happened people started with so many dreams with this plant. Because they thought: plant does not have any disease, it can grow without water, etc. etc. and after four-five years, there was no yield up to their expectation, though the plants were growing very well. So slowly and steadily, the commercial they could not they could not get from the plant. The cultivation will be very expensive, the way they want for the yield. Earlier we experienced, it is disease free, can grow in less water. But later on, the case was different. The plant requires a lot of management and money.

The respondent goes on to express precautions over the adoption of jatropha cultivation:

> Unless more research takes care of disease and pest problem, it is not a time to give to farmers. Other round of preliminary support is required in order to plant at commercial level. We are not targeting the fertile land at all and it should be discouraged. Because we are importing edible oil, and the preference should be given to edible crops in fertile lands.

The differing opinions of scientists on the adoption of jatropha as a biofuel feedstock mentioned above project a scenario where there is a lack of consensus among the scientific community. Indeed, in the background of such disagreement on the cultivation of jatropha, the response of Laxmi captures the current scenario of the plantation in her village Manavto ka Guda, Rajasthan:

> Some scientists thought that it's a good crop, it safe from grazing, it gives good yield. They imagined that nothing can harm the crop. This thinking is fine. But, at least one characteristic should be correct, but noting came out correct. The thing is that appropriate people did take appropriate decision.

Nagesh, another participant from the same village has similar opinion on the expectation from the scientific community:

> What farmers require, is more yield with less water, less fertilisers, with less pesticide. If one can really convey this, farmer would be happy. Farmers want some money. Some agricultural practices during draught time, heavy rain, and value addition to the harvest in terms of oil, cake etc. these are few things which farmers expect from the scientific community.

Further, from the interviews with the farming community, it emerges that they either willingly or forcibly agreed to cultivate jatropha, hoping their problems would end with this wonder crop but they were mistaken. Sufficient research had not been carried out on the right variety to be planted, the yield was far below the promised level, and the farmers were not trained in the appropriate pruning techniques, and the dismal output enhanced their existing burdens. In the words of Harpal, one of the participants from Mangeli, Madhya Pradesh, jatropha has not been so optimistic for his village:

> Four years have been passed, I can see there is no profit in *ratanjyot*. Farmers see more more profit in sugarcane and capsicum. That is why they are shifting to other profitable crops, that may be the possibility. Some farmers in my village are doing better with these crops [capsicum and banana] than the other farmers because these farmers do not have sufficient and correct information about such profitable crops. They are not well educated, when to apply *dawa-pani* (chemicals and water). If they know all these complexities of these cash crops they can also do it, and will stop jatropha cultivation.

On the similar line one of the participants from Godhi village, Chhattisgarh, an ex-sarpanch of the village panchayat, is critical about jatropha plantation as one of the measures of rural development. She states:

> Jatropha plantation is also there. People from abroad came for the plantation. At time of plantation event we thought that a good number of people would be benefitted from it. But years have been past, we are not seeing a new development, only a few people are involved with it. Large development project is the solution of problems the village is facing.

She goes on to support large scale industries for the development of the village:

> Bhilai Steel Plant (BSP) is the perfect example. Earlier we used to reside in that area where the BSP has been built. Fifty three villages were evicted then

only BSP could established. Today, can anybody question BSP? Those villagers sacrificed their home and land for the BSP. Today lakhs of people are benefiting from the plant. If the BSP would had not been here, this region would be like Bastar. Now these people have forgotten this. These people and their family members working in the BSP. There is no problem, if hey are working in BSP, but some common person wants a job of your own village, you are creating obstructions. This is not good thinking and approach. You are earning fifty thousand per month and if there is a possibility some other is in position to earn five thousand you have problems. If this is the attitude, one cannot process. These people are not thinking about the development of country, state, and their own village. Their only concern is their progress not of others.

4.7 A Case of Positive Effect of Jatropha Plantation

The previous section discusses the implications of the biofuel policies and missions on the rural farmers and labourers, and emphasises that the pro-poor development initiative could not cater to the interests of the farming community. However, during the fieldwork some of the rural users express the benefits associated with the NMB and the NPB. Some village communities are able to manage contacts with the NGOs and private companies and also manage their own jatropha plantations, while a few individuals cultivate jatropha as their own business opportunity and have benefitted from it. Tenner (1996) has emphasised a phenomenon "reverse revenge effects" and argues that unexpected benefits can also emerge from a technology when it is adopted differently, or used in unforeseen ways. For example, one of the participants Nagesh Devangan from village Godhi, Chhattisgarh, was a landless farmer who took a loan of Rs.5000. He did not own any land of his own, hence he leased land and cultivated saplings. He set up nurseries of the plants that were in demand. He normally prepared saplings of mango, jackfruit, guava, chillies and ginger, and had experience in maintaining nurseries, and after a few months he sold the saplings to the farmers.

Despite being in the business of maintaining nurseries he did not make sufficient money because of the level of competition from farmers who had larger nurseries, and also, he did not own any land of his own and had to rent land. In the year 2005, he first heard about jatropha and its benefits, and when A.P.J Abdul Kalam, the erstwhile President of India, visited Chhattisgarh and spoke about its essential qualities and viability he was keen to plant jatropha. He did not follow the other farmers and planted jatropha to sell the seeds. He accommodated the technology in to his existing system of nursery plantations. He invested in nurseries of jatropha and sold the saplings within three to six

months. None of the other farmers were doing the same thing and while they waited for three years for the plant to yield seeds, Nagesh said that he sold the saplings to the farmers, biofuel companies and research labs. The farmers bought saplings from him because most of the time many of the seeds were of bad quality and did not grow, whereas buying saplings was a safer mode. Biofuel companies preferred saplings so that they could directly plant them in the tilled soil, and research labs preferred saplings because they could study the growth characteristics in a shorter time period. In 2008 he raised 25 lakh plants, by 2013 it had increased to 1 crore plants, and by 2017-2018 he had more than 2 crore plants. In the span of four years not only did he return the loan amount he borrowed when he had left his village, but also he bought his own land, set up his own nursery.

4.8 Value-Chain of Biofuel: Governance and Control of Biofuels

In the previous section we made and attempt to present one of the cases of optimistic outcome from jatropha plantation. The case brings up the linkages of the farmer with industry, research institutions and other farmers interested in enrolling in biofuels network. In this section we attempt to foreground the role of the state biofuels development boards and the NGOs on building a value chain for biofuel. This value-chain includes the promotion and distribution of jatropha seedlings and saplings, collection of jatropha seeds for further processing, marketing of the processed oil, and the role of agricultural extension programmes in these processes.

As we have mentioned in section 4.1, the biofuel network in Chhattisgarh represents the government-led initiatives in the biofuel promotion and production. The Chhattisgarh Biofuel Development Authority (CBDA) is the nodal agency of the state for biofuel production and distribution. The officials of the Chhattisgarh Biofuel Development Authority claim that they have developed a systemic, comprehensive and unique biofuel programme which is complimentary to farming activities. According to the CBDA, the concept of biofuels for rural energy independence and the strategy adopted to incorporate it in agricultural system are unique. The CBDA focuses on the identification of appropriate plant species. One of the officials from the CBDA explains:

> Selection of suitable plant is given utmost importance. The team of scientists travelled across the state and identified candidate plus tress of different non-

> edible oil yielding species of jatropha exhibiting high seed yield and oil contents. Identified lines of these species were multiplied and made available elite planting materials to the farmers. Research activities in several direction in progress and are successful in implementing many programmes complementary to the activities.

Further, the CBDA aims to develop and provide technology and model for production of biofuels across Chhattisgarh, and tries to replicate the practices and programmes that can involve the farming community at a large scale in the biofuel programme. The model developed by the CBDA encompasses thrust areas of biofuels promotion by extending the programme activities to all the districts of Chhattisgarh. According to one of the officials from the CBDA:

> We are encouraging the stakeholders to adopt appropriate sustainable technology and path to achieve the goals. Objectives of the biofuel programme which we have developed are to motivate farming and other sectors to take lead roles on adopting biofuels as a sustainable option of energy. The biofuel authority has completed almost thirteen years and it is successful in achieving the set objectives of conducting research, identifying elite lines, standardisation of protons and methods of trans-esterification of oils, designing oil expellers, decorticators, trans-esterification units, creating awareness among farming community, conducting training programs, setting up nurseries of elite lines, providing planting materials and arranging planting in identified land areas, and so on.

In addition, to that the CBDA has developed an effective information system. The information is given to the farmers at their doorstep by a group of field investigators. It has covered 2110 villages in Chhattisgarh, has conducted 3000 awareness meetings, and 1633 training programmes have been held in the entire state (Source: Field Study). In these training programs and awareness meetings, about 110000 farmers and interested people participated, and out of this around 50 per cent were women. The outcome of all these efforts is that now 470 oil seeds growers and the collectors' associations have been formed, and seventy villages have been designated as "complete biofuel village" with every household planting a biofuel species (ibid). Around two million seedlings of jatropha have been distributed and covered twenty thousand acres in the districts of Chhattisgarh. For continuous supply of these seedlings, the CBDA has established a model nursery of identified plus trees at the biofuel park. Grafting techniques are also adopted to produce quality planting material and to get higher yield within shorter time. According to one of the officials from the CBDA the gross analysis of economic outcome

of the biofuel programmes is encouraging. During the last five years (2014-2019), three lakhs labour days of employment has been generated that turns out to annual income generation of Rs.2.5 crores. The biofuel programmes have helped the farmers to generate employment of about 30 labour days per household with income generation of about Rs.15000-30000 per household per year (Source: Field Study).

In the case of Rajasthan we identify private companies and NGO led biofuel programmes. In this state, private companies and NGOs engaged in biofuel programmes conduct survey and mapping of other biofuel feedstocks, including jatropha, such as used cooking oil and acid oil coming medical processes. The private companies convert these feedstocks into biodiesel in order to supplement the requirement expected from jatropha oil. Similarly, there are various programmes initiated by NGOs to promote biofuels in the state. For example, an NGO is running a programme *Chetna* in coordination with the district council. The district council plays an important role in mobilising and mapping of biofuel resource in the district. The programme *Chetna* encompasses various renewable energy implements which are not confined to biodiesel only such as ethanol, biogas and solar energy. In the words of the official from the NGO:

> We know whatever petrol we are getting from the market is ethanol. Ethanol is coming from, sugar, i.e. from molasses. We also know about lignocellulose, which can be converted into ethanol. Management of liquid waste and solid waste, that can be converted into biogas. These are the options, and we are giving emphasise to all including biodiesel. When you are talking about broad concept of bioenergy: one is ethanol, another is biodiesel, and the third is biogas.

In addition to this, the information and demonstration centre exists in 12 districts of Rajasthan for biofuel related programmes. These centres have been provided with funds to purchase seeds from the farmers. Biofuel park and biofuel mart in these 12 districts connect the farming community and the market. In these mart biofuels related products are available at a single place. For example, the farming community can purchase seedlings, seeds, cake and manure of jatropha. And, if the farmers expel the oil after the harvest, they can also sell it in the mart. The mart promotes the exchange activities between the farming community and the market. Moreover, there marts organise biofuel awareness programmes for the public. One of the officials from the Rajasthan Biofuel Authority, Jaipur, elaborates on the activities of the biofuel marts:

> Through biofuel mart we are concentrating on Information, Communication and Education. Here we are including other stakeholders, like NGOs, University, Students, industry and business people, other than farmers. We also organise and celebrate the International Biofuel Day every year on 10th August. In this occasion, workshops, training, biofuel plantation drive are conducted throughout the state. Each year we select some student projects from engineering colleges in association with the Maharana Pratap University of Agriculture and Technology, Udaipur. Around 200-250 entries we get and out of which we select fifty projects, and we avoid repetitive projects. Some innovative, creative and case study based projects, keeping the these things in mind we select these projects. Out of these fifty projects have started working professionally, some are focussing on quality parameters, a few are developing standard operating procedures.

However, one of the participants from Devla village, Rajasthan, shares a different experience on the variation of price of jatropha seeds in spite of the existing biofuel value-chain in the state:

> People from India as well as from other countries got interested in jatropha. Due to this we have seen the price of seeds surged from two rupees per kilogram to eighty rupees per kilograms. A large quantity of seeds started to coming to market. Initially people were buying these seeds as planting material. Some private companies like Ruchi Soya, Reliance, Emami, D1 oil purchased seeds from here. They purchased the seeds in large quantity and high price. As later on demand of planting seeds decreased, subsequently, the price also went down. But still price of the seeds is fifteen rupees per kilogram, because the demand is still there. Otherwise the price would have decreased more. Now people know the usability of jatropha, how oil can be extracted and used as diesel easily.

In the case of Rajasthan we observe the consortia of private companies and NGOs supplemented by the state biofuel authority. We have also discussed the Chhattisgarh's government-led biofuel value chain. The case of the third field site, Madhya Pradesh, presents a different scenario where biofuel value chain is dependent on the research-led network. According to one of the scientists from the Jawaharlal Nehru Agricultural University, Jabalpur, which is the 'centre of excellence' in biofuels:

> Ultimately farmers have to do it at large scale but not in arable land. We have provided them techniques, packages, practices for how to improve productivity, how to improve your soil. We have also organised some farmers' meeting and educated them about plantation. We have developed nurseries for jatropha. We collaborate with department of agriculture, and

> department of forest for developing jatropha nurseries. We distributed the seedling to the farmers and forest departments. They plant these seedlings in margins of farmland, arable community land, and revenue land of forest department.

The centre of excellence in biofuels provides training to the farming community. The centre focuses on the various species of jatropha, where these can be grown and expected output can be obtained from the cultivation. Furthermore, the centre introduces the farming community with oil expeller machineries, marketing facilities and the cost involved in the cultivation and harvesting. Once in a month the centre organises a training session as per the convenience of the farming community. Every time the representative of the centre visits different villages, and arranges a programme for a particular village. When the harvest season starts the farming community approaches the centre or the centre contacts the farming community for the collection of the seeds. After the accumulation of seeds, the centre engages the farming community in preparatory works such as screening and cleaning of the seeds, and segregation of different quality of seeds based on certain parameters.

However, the centre of excellence in biofuels is experiencing resource crunch to expand its activities. According to one of the respondents from the centre:

> Here not much of support is provided from national agencies. However, some projects are funded by the Department of Science and Technology for the development of plant through the clonal selection. We also collaborated with some international agencies like the World Agro-Forestry Centre to promote our dwarf variety. We also have well established extension system through which we reach out at village people and conduct some awareness camp, training camp, on-campus training camp to build human resource who can take this biofuel programs. But for these extension activities we have limited funds.

Nonetheless, the respondents are optimistic about the future of jatropha as one of the feedstock to address the demand of energy:

> That time they have given lot of type to jatropha, I am not saying that is wrong. That was the momentum, the beginning. It created a pathway, but developing a trust is a big deal. In initial stage creativity and vision are more important. Whether jatropha have failed or passed, this is immaterial at this stage. Actually, jatropha has created a way to think on those lines. We should

> never say that jatropha is failed or pass. You, as a researcher and the centre as an institute what we can contribute for biofuels, that is more important.

The representatives of the centre are of the opinion that some of the farmers are successfully engaged in jatropha cultivation and they have started getting benefits from the cultivation. The centre also promotes the use biodiesel produced after the harvest within the farming community in order to complete the value chain, so that they need not to depend on the market for trading of the produce. In the words of another scientist from the centre:

> Locally they have lots of species, we want them to get aware of properties of these species. They know about these plants, but what usability can be harness from these plants. Let them utilise themselves, make utilise this oil at their own end. Like in case of jatropha, they extracted the oil and used in their tractors. Farmers are using the oil in most of the agricultural machineries, tractors, irrigation pump sets where up to twenty percent of oil is blended with diesel. In conventional engine we do not advocate direct use of this oil. This oil is converted into biodiesel and by blending with diesel it can be used safely.

The centre of excellence in biofuels in Madhya Pradesh assists in the formation of the farmers' group to strengthen the value chain of biofuel production and consumption. These groups are engaged in backward and forward linkages. For example, the collection and processing are done at the village level so that the biomass can be used within the village. Similarly, post-harvest machineries are installed in the villages in order to facilitate the consumption of oil and cake[19] within the villages. And, if the production of oil and cake is in surplus it can be sold to the industries to create the forward linkages.

The approach of the centre of the excellence in biofuels indicates the dissemination of biofuels at the local level. It emphasises on the decentralised nature of energy and its accessibility and consumption which is in contrast to the motives of the NMB and the NPB. The Government of India aims to implement biofuel programmes in the circumstances of assumed energy crisis owing to the depletion of fossil fuels (GoI 2003, 2009). Here the preference is given to fulfil the demand of transportation sector and the grid electricity by biofuels. These systems represent a centralised approach of energy control and consumption.

[19] Residue of jatropha seeds after oil expelling process is used as organic manure.

The implications of technological control have been discussed in 'Do Artifacts have Politics?' by Langdon Winner (1980). Winner draws upon the inherent political characteristic of technology by sighting Lewis Mumford's exposition of nuclear energy and the state control. Similarly, Visvanathan (2007) states that energy imparts a rationale to the state for control and discipline. Energy has to be planned, measured and channelled. He goes on to argue that energy is strongly linked to control and discipline that leads to stratification of energy. The state's preference to energy sources like petroleum, hydel, nuclear and thereon electricity puts them on higher strata as expert energy. Expert energy is scientific energy and therefore the official energy. On the contrary, energy generated traditionally by fuelwoods and dung by the people is considered immeasurable and nonconvertible, therefore it falls in the strata of unofficial and non-scientific. The question arises, what would have been the reason to call it non-scientific? Perhaps, it is the inability of the state to control and discipline in the scenario of decentralised energy production and consumption.

4.9 Is Biofuel Green? Case of Environmental Politics in a Village

In the previous section, we attempted to juxtapose the promotional claims of the biofuels with the experiences of the farming community as the end user of biofuel technology. In this section, we attempt to foreground the social dimension of knowledge vis-à-vis expert knowledge, and further, we try to look into the formation of identities of an individuals or community in a village of central India where biofuel has been promoted and produced since 2003 with the launch of the National Mission on Biodiesel.

On the one hand, the narrative of jatropha promotion embeds local characteristics which can attract the farming community such as jatropha is a drought-resistant, perennial plant living up to 50 years and has the capability to grow on marginal soils. It requires little irrigation and grows in all types of soils, thus making jatropha a more sustainable choice than other vegetable oils. Jatropha biodiesel can be used for decentralized micro-grid electricity generation at the village or taluka (suburb) level and as a replacement for diesel fuel in irrigation pump sets, diesel generators and also as an alternative to kerosene. On the other, jatropha is promoted as a renewable source of energy which can address the energy crisis, mitigate climate change and a green fuel in order to fit in the broader

imaginaries of development in India. For example, one of the scientists from the Defence Institute of Bio-energy Research, Haldwani, proclaims that:

> Self-reliance in energy supply is vital for the economic development and national security for the nation. World has very limited reserves of fossil fuel which is expected to be exhausted within twenty to twenty five years. Seventy per cent of demand is being fulfilled by importing oil from oil producing countries of which eighty per cent consumption is in the form of diesel. Thus, an immediate need to search alternative, renewable, non-polluting, sources of energy to avoid any eventuality arising out of the supply interruption due to international fluctuating political and strategical scenario of the oil producing countries. To avoid this situation, attempts are being focussed for bio-energy utilisation as an alternative source of energy in our country. The non-edible vegetable oil from jatropha plant has been selected and DRDO has initiated a program on jatropha as per the directives the then Defence Minister.
>
> Rapid international exploitation of fossil fuels and plateauing of domestic crude oil output have compelled the search for indigenous renewable and viable source of energy, leading to focus us on biodiesel. Our vision is to look forward for a green, healthy, pollution free environment. To make nation self-reliable in fuel industry and to gift the future generation with eco-friendly, replenishable fuel resource. Our mission is to develop decentralised people oriented model, system and strategies the production of biofuels. To provide knowhow on biofuels from lab to layman's platform and educate them regarding long term advantages of biofuels and, to provide end to end solutions for biofuel programs with appropriate technologies and market network.

Laboratory studies of the 1980s (e.g. Latour and Woolgar 1979) has made the shift from common understanding of "knowledge as system to understanding" to "knowledge as process". Scientific knowledge and practical knowledge are constantly recreated and upheld because they help the different individuals and institutions to position themselves among their peers and within communities. The excerpt of a case of Godhi village, Chhattisgarh, captures the juxtaposition of this case and the previous respondent (the scientist from the Defence Institute of Bio-energy Research, Haldwani) to understand the politics of environment at the local level, although which is not at all isolated from the global politics of biofuels.

> Now in many families nobody is active in village politics, either in the election of *panchayat* or *sarpanch*. Politics is so bad that it can destroy a simple person. My father is a very simple man, even today ninety percent of the villagers listen to him. If he would contest for *Vidhayiki* (member of the legislative assembly) he can easily win. But some people have damaged his

image so badly in the case of beer plant that he is not able to recover from that shock of defamation. Around five to six years ago there was a proposal to set up a beer plant. Beer was not going to produce here but from the Indore plant, only bottling and storage were the purpose here in this proposed plant at our village. Husband of the previous Sarpanch, who is also relative to us and a very close friend of my father, opposed so fiercely to my father who was sarpanch at that time, just to create a space for the candidature for his wife in coming election for the post of sarpanch. Because of that protest our family submerged in debt of seven lakh of rupees. The company who was planning to set the plant gave sixteen lakhs for the village on behalf of getting the no objection certificate (NOC). Out of that two lakhs were taken by *dalals* (mediators), and rest of the money was distributed among the other 40-50 villagers including *panchs*, so that people of this village would not do any protest for the plant. My father got only one and a half lakhs out of that huge money.

It was expected that this plant would bring a few facilities for the villagers, employment, education, etc. There was an agreement on five points: the company will put effort for development of the village, will open a college, a bigger hospital, construction of dams and plants. But people could not understand this, they were misguided by the person who is my relative and opposed the plant. Similarly, these people also protested the seed plant, in the name of pollution. These protests let village down, otherwise Godhi would have done better than Murmunda (nearby small market place serving the needs of nearby villages). But the political greed for becoming the sarpanch of Godhi destroyed the future of this village. Earlier this village was famous in entire region for its peace, fraternity, and hospitality; now after the protest the village has divided in factions, rivalry, and distrust. During that protest our family was not able to go out of home for three days. Entire village was gathered in front our house with tents and mike. It was a torturous to us, it was illegal also, but nobody came to our rescue. Till date we have not recovered from this trauma.

Other projects were opposed in the name of pollution. The sponge iron factory was fortunate, I think because it was the first one in this region, tough it is more polluting than the other proposed projects like seed plant and beer plant. And our village was less affected by pollution from this iron factory and other village like Kapasdha and Akola, because usually the direction of wind is in the direction of these villages. These village were severely affected by the iron factory. Other projects are also there, people have taken NOC and purchased the land, but after that protest, nobody is daring to start any project in this village.

In the case of Jatropha plantation there was no protest, because it is a government project and it is for the *Paryavaran Sanrakshan* (environmental conservation). Now there is a proposal to set a biofuel expeller plant beside the plantation. The NOC has not been requested by the authorities yet. I do not know what would be the fate of this biofuel plant by looking at the attitude of the village. Here the number of people is more those who do not understand (*Yaha nasamajh log jyada hai*). At least 200-300 people would

> have got some job by those projects, and unemployment would have vanished from our village, but people could not understand this. Now they are thinking and regretting. The youth of village is jobless, now the protesters are realising.

The above case depicts the aspect of development through industrialization arising conflicts of power and over resources. As per the Centre for Science and Environment's (CSE) study in 1982 "*conflicts in development processes are essentially conflicts for control of these [natural] resources. The protest and struggles make compelling associations or connections between politics, the environment and resource inequalities*" (Agrawal and Narain 1996).

Environment movements in India, in fact, can be characterised as a type of "*environmentalism of the poor in so far as they have combined green ecological concerns with the red of class politics*" (Guha and Martinez-Alier 2000). The 'environmentalism of the poor' as a typology to explain new social movements in India, however for Baviskar (2008: 171), environmentalism, instead – as a form of political struggle – is shaped through a series of connections made between the "*environmentalist representation of social movements, the nature of capital that they oppose and their collaborations with metropolitan audiences and interlocutors*" (ibid: 172). Here, Baviskar is arguing in sharp contrast to Guha and Martinez-Alier, that discourses on environmentalism in India have in fact drawn upon a range of sensibilities, ideologies and negotiations between varied groups and interests. In effect, social movements that have been characterized as ecological struggles against development initiatives have not only been 'ideologically hybrid' (Baviskar 2008), but interests and meanings are closely embedded in the strength of these challenges that have been deliberately or otherwise kept 'ambiguous and shifting'.

4.10 Conclusion

This chapter dwells upon impediments and risks involved in the cultivation of biofuels, particularly jatropha, from the perspective of the farming community. We attempt to juxtapose responses of the farming community and the scientific community against the backdrop of global promotinal claims and oft-excluded narratives of biofuel adoption. We start with introducing the sites of data collection and identify three types of biofuel

network, namely, governemnt-led, research-led and private companies and NGO-led, respectively in the state of Chhattisgarh, Madhya Pradesh and Rajasthan.

During most of the conversations when participants are asked about jatropha and what they think about it, it is observed that different participants associate different meanings with the crop. In some villages, the Sarpanch associates jatropha with money, subsidies, prosperity, while the labourers cultivating it on common property resources consider it a bane, waste of time, and associate it with subjugation by the government. The discussion demonstrates how the Sarpanch who was paid money or approached by the government officials suggests only merits about jatropha while those who are forced to cultivate it have not-so-optimistic experiences with the plantation. A few farmers associate jatropha with money and an opportunity to buy new stoves, clothes, small-scale farmers associate it with extra income, and some villagers associated it with energy to run their pumps.

In our discussion on the nature and mode of engagement with jatropha plantation, we observe the process of classifying land as wastelands as an example of state oversimplification. There are certain state processes such as establishing land and population surveys that are undertaken to decipher the actions of populations, which in turn augment the state's ability to monitor its citizens. These processes often simplify "complex, illegible, local social practices" (Scott 1998: 2) and often they fail in their goal of improving the human condition (ibid.). Such schemes or initiatives have the potential to modify or change the landscapes of the communities they operate in and subsequently alter the relationship between the state and its citizens. The NMB and the NPB are such processes that alter the relationship between the people and the government when the common property resources are termed as wastelands and diverted for the cultivation of jatropha.

The rural population comprising landless labourers and marginal farmers are told that they could not use the common property resources for grazing or cultivating subsistence crops, instead they have to grow jatropha on it. The widespread diversion of common property resources for the cultivation of jatropha leads to disputes and displacement of farmers, especially in Chhattisgarh, where the officials are keen to implement jatropha plantations. Despite protests from the people, the state government continued with the plantations.

Then we move on to illustrate the implication of jatropha cultivation for the farming community. Jatropha is being publicised as a hardy crop that is resistant to pests and requires minimum inputs, but the farmers observe that it is susceptible to pest attacks, termite attack and its yield rates get reduced markedly without inputs of irrigation and fertilisers. We also observe the conflicting opinions on the pruning method, development of the variety and hybrids. The consequence of this appears in quality and quantity of oil produced from jatropha that varies significantly across different genotypes of the seed. Another major concern is the model of contract farming adopted by domestic and international companies which having drastic implications on the rural farmers, in turn being contradictory to the development goals of the project.

The last two sections depict the governance of biofuels in all the three field sites. In this process we discuss the value chain of biofuels in different states, agricultural extension programmes and centralised nature of energy control. We argue that agricultural knowledge extension must consider the historical and social environment it operates in as we see in the case of village politics over power and resources. Thus, agriculture extension programme for biofuels is a manifestation of relations of the different purposes and agents involved, not merely the environment sustainability or assumed energy crisis.

In the following chapter we will summarise the findings of the present study. We attempt to situate this dissertation within the broader frame of science, technology and society. Then we move on to identify the limitations of the present study and scope for further research.

Chapter V
Conclusions

The present chapter summarises the findings of the study and attempts to situate its contributions to Science, Technology and Society (STS) studies. Further, the present chapter identifies the limitations of the study and explores the scope for further research in the field.

5.1 Summary of the Findings of the Study

The aim of present study is to locate the trajectory of jatropha and its construction as a biofuels crop in India. Biofuels as an act of doing is promoted for manifold societal benefits. It is neither possible nor desirable to abandon the persuasion of technologies as policy instruments for the 'development' initiatives. Therefore, the study dwells upon the role of the state, private companies and other public sector institutes as promoters of biofuel technology and dissemination of the same as a sustainable source of energy. The findings of the study are based on the responses of the scientific community and the farming community engaged in the promotion and production of biofuels respectively.

The study is divided into five chapters. The first chapter introduces various facets of the thesis such as review of literature comprising discourses on biofuels within the theoretical frameworks of STS, research gasps, rationale for the study, research questions, objectives of the study, methods of analysis and structure of the study.

The second chapter provides the global and Indian experiences of biofuels. We have discussed the rise of biofuels and biofuel policies world over and how many developed and developing countries have either formed or are introducing biofuel policies, mandates, and missions. Biofuels are important not only as a source of renewable energy but also as a solution to address rural development issues. Following the global trend, the Government of India started biofuels programmes to address energy security, rural development, climate and environment mitigation. We situate the National Mission for Biodiesel, 2003 and the National Policy on Biofuels, 2009 in the frame of sociotechnical imaginaries. We argue that technological projects for energy are presented to imagine a

future which is feasible, attainable and desirable for social necessities and order. We foreground the debate on energy, equity and justice by juxtaposing the ideas of nationalist leaders at the time of India's Independence on the one hand, and on the other, Seshadri and Visvanathan conceptualise an equitable society based on biomass energy. Biomass societies are not based on "second-rate science for a second-rate society" (Visvanathan 2007: 198). Biomass and high energy (oil and nuclear) have been portrayed as dichotomies in terms of rating. Whereas biomass represents the satellites, high energy represents the metropolis. This rated division pushes for a distorted understanding where biomass is taken as the discourse of the defeated. On the contrary, the Vietnam War exemplifies when a biomass society pressed its resistance over a regime anchored on high energy.

The genealogy of wastelands in colonial and postcolonial India indicates that the classification of land into marginal or wasteland is not the first instance which surfaced with jatropha cultivation in 2003. Rather the politics of wasteland classification has had a history of development initiatives in both colonial and postcolonial regimes. The comparison of postcolonial wasteland programmes and the current biofuels policies and mission reveals the striking similarities such as the emergence of crisis narrative with impetus of international development factors, response of the government to such perceived crisis, appointment of high-level committee to address the crisis, ambiguous assessment and monitoring of wasteland and promoting these measures as an inevitable step for rural development. These similarities foreground an assumption of abandoned land which is unproductive and hence not in use. By wasteland development programmes unused land can be assessed and improved for larger welfare of country. Against this backdrop of crisis narratives and wasteland development programmes that the idea of 'land improvement' paved way for the emergence of biofuels crops in India, not the urge for biofuels itself.

The discussion on the exercise of wasteland mapping by the government agencies suggests that land categorisation has been in a state of continuum in both colonial and postcolonial regimes. The perceived conflict between timber and fuelwood, respectively for industry and household, underlies in the creation of social forestry programme. The Government of India has been steadily expanding areas under social forestry and in turn wasteland development programmes to address the land degradation and assumed

conflict of timber and fuelwood. Where earlier approaches focused on isolated land patches, the shift came with social forestry was to incorporate the contiguous block for development. Estimates of wasteland assessment vary from 38.4 million hectares to 137 million hectares in India owing to the continuous shifts in identification and categorisation of wasteland assessment. This broad range makes it difficult to derive a conclusion whether area under wasteland is increasing or decreasing over the years.

The process of biofuel network formation elicits the role of various actors in the creation of the policy network. We draw from the ANT by Callon, Law and Rip (1986), Law and Hassard (1999), and Latour (2005) to emphasise the importance of networks in policymaking and in extending development projects, and show how actors form successful alliances to take a project forward. We illustrate that for any new initiative to be introduced in a country it has to be supported by a network. Here we elaborate on the emergence of the biofuel network at the central level where the key actors are bureaucrats, politicians, scientists and representatives from the industry. The discussion reveals the role played by the actors from different ministries in supporting the biodiesel initiative and actively promoting it. The NMB targeted the development of biodiesel as a viable technology and cast jatropha as the most suitable oilseed for the production of biodiesel. The discourse reveals the interpretative flexibility of promoting this initiative and how various actors align themselves with it.

Further we move on to illustrate the perceptions of the scientific community, policymakers and officials engaged in the biofuel programme. The discussion finds Jatropha was introduced as an implement of land appropriation by the Government of India, and subsequently as a feedstock for biofuels against the backdrop of assumed energy crisis. We find that the stakeholders have differing perceptions on identification and management of land, and selection of jatropha as a feedstock, which do not often submit to the claims made in the biofuel policies. From the responses of the scientific community we infer that jatropha was promoted under blanket policy all across the country and biophysical conditions of the location were ignored while framing the NMB. However, analysis of the land management indicates that a majority of the scientists (78 per cent) identify wasteland where nothing can be grown. Moreover, the land which is empty is considered s wasteland. Such understanding of wasteland and thereby land

management align with the motive of the NMB. Therefore, it creates a situation where socio-cultural dimensions are often ignored at the time of the cultivation of biofuel plants.

The third chapter depicts the interaction between jatropha and the scientific community in the background of diverse ways in which research and development on jatropha is carried out in social, political and technological facets. Here the discussion is focused on capturing the materiality and agency of jatropha, discursive nature of scientific claim-making in biofuel promotion or opposition. The analysis suggests that the materiality and agency of jatropha manifest in temporal and performative ways during the process of dialectic of resistance and accommodation in scientific practice. Further, it indicates that the materiality of jatropha plant appears in the contours of time, domestication, variety development, response to disease, suitability and sustainability of the plant, and environmental and biophysical aspects. In the context of temporality, 76 per cent of the scientists perceive time as a dominating factor for research and development in general and especially in the case of jatropha in particular where time allotted by the government and funding agencies is quite limited. In addition to this, we observe that materiality of jatropha also manifests in terms of seasonal change that affects the expected growth and yield of the plantation. Thus, the promotional claims made in NMB could not be corroborated owing to unpredictable behaviour of jatropha which is contingent on the time.

In addition to the time, the biophysical aspects such as soil, water and fertiliser facilitates jatropha to exercise its materiality. The discussion highlights that 18 per cent scientists acknowledge the limiting conditions of the nature of the land, and emphasise on soil preparation prior to jatropha plantation. However, 64 per cent scientists opine that deficiency of water and fertiliser affects the yield of the plantation, and it is not an exclusive condition for survival for jatropha plant only, though there are instances of employment of multilocational and multispecies for biofuel feedstock to address the resistance extended by jatropha in varying biophysical conditions. Thus, the study infers that the biofuel policies and the scientific community often ignore biophysical factors mediating with jatropha while introducing the plantation across India. However, 16 per cent of the scientists cautioned about the plantation in large scale without considering biophysical factors. Nonetheless, a single umbrella policy on biofuels was implemented

across the country without taking humidity, temperature, soil and land topography into account.

The discussion on domesticating jatropha demonstrates that jatropha is not native to the Indian subcontinent, it has origin in the South American continent. Therefore, it has less variation and has not optimised the environmental conditions in India. The scientific community is engaged in developing varieties and hybrids that are suitable for varying geographical conditions of the country. Around 72 per cent of the scientists point out that hybrids need to be developed through multilocation trials to acquire the best quality germplasm in order to domesticate jatropha.

On the one hand, the scientific community emphasises on hybrids and variety development, and, on the other hand, they do encounter resistance from jatropha. The analysis indicates that in the process of domesticating jatropha, variety development emerges as one of the taming instruments to capture the material agency of jatropha. Around 71 per cent of the scientists comment that a lack of jatropha varieties during the commissioning of the NMB in 2003-2008 leads to not-so-optimistic outcome from the biofuel mission. Against the backdrop of less varieties 20 per cent scientists have had apprehensions about large scale jatropha plantation. The development of a variety is also coupled with the aspect of harvest which would be convenient for the farmers. For example, a few research institutes selected for the field study are engaged in developing dwarf varieties with synchronous maturity.

The biofuel missions and policies project jatropha as a disease resistance plant and it can be thrived without water and fertiliser. On the contrary, our discussion suggests that 76 per cent of the scientists are of the opinion that jatropha can survive without water and fertiliser, but the yield would be lesser than the projected quantity mentioned in the biofuel policies. One of the concrete findings of the present study is that 82 per cent of the scientists acknowledge the weaker immunity of jatropha. The scientific community points out that jatropha is susceptible to various diseases, viz. pests, termite, fungal, insects, virus infection, etc. owing to which it is not fully domesticated, and we witness scarcity of appropriate varieties and quality material for the plantation. However, we argue that these problems encountered by the scientific community are the manifestations of the agency of jatropha which mediates through resistance during the scientific practice.

Moreover, we argue that the development of variety and hybrid is employed in terms of accommodation from the scientific community to address the resistance presented by jatropha while mediating with the elements of biophysical, domestication and disease resistance.

In our discussion on discursive flexibility of jatropha we find out that jatropha does not possess the high material flexiblity as it cannot be consumed as food and can only be made into livestock feed if it is first detoxified, unlike other potential sources of biofuels. Despite the low material flexibility, discursive flexibility has helped make the 'jatropha project' resilient in the face of failure. However, jatropha's low material flexibility appears to be a unique feature among biofuel crops. Owing to the reason that a few marketable products can be made from jatropha, and markets for these products are not well developed, it is not easy to shift from one value chain to another, for example, from biodiesel to soap. For crops such as oil palm, energy production adds another layer to a political economy that already includes food, feed, commercial or industrial products.

Further, the discusson reveals that much of jatropha's discursive flexibility comes from the idea that it can achieve different sets of goals depending upon which the production model is used. The discussion indicates that the actors in India equate large scale jatropha production with national and international goals as well as small scale production for local use with household or community goals. The idea that different outcomes and benefits for different groups of people can be achieved by choosing among several possible production models can also be understood as discursive flexibility. Unlike the decision of which product to make, the choice of production model must be made early on that involves considerable lock-in. It is not easy to change between large scale plantations, small scale production for local use and/or nucleus-outgrower arrangements once they are underway. Invoking the flexibility of different production models is therefore a discursive tactic.

Paradoxically, jatropha's low material flexibility has helped posit it as a 'sustainable' energy source. In terms of its ability to attract investor and government support, jatropha's high discursive flexibility appears to have compensated for its low material flexibility. Owing to the reason that actors have been able to portray jatropha as capable of simultaneously achieving national or global goals related to economic growth and

climate change, and community goals related to livelihoods and local ecologies. Changing the stated reason for growing jatropha in the absence of a relevant value chain and conflating the expected outcomes of different production models provide examples of discursive flexibility at work.

In the section on scientific claim-making, we refer to Pickering's "mangle" in the process of resistance and accommodation performed by actants and actors and how they set the locus of any scientific experiments in the context of environment discourses. Here we discuss the interlinking of discursive flexibility of jatropha and environment. We infer that the opinions on the merits and potentials of biofuels as a renewable and sustainable source of energy are polarised. We identify the presence of pluralistic narraritives in both propmotion and opposition of biofeuls in general and particularly jatropha in the case of India. We have categorised the contestations among scientific community into three perspectives. First, the reductionist bio-processing perspective favours the employment of biofuels in the wake of depleting fossil fuels. Second, the holistic bioscarcity perspective focuses on the adverse consequences of biofuels. And, the third perspective has apprehensions over the adoption of biofuels. However, the third perspective favours the use of biofuels at the rural level, and not at the industrial level.

The fourth chapter explores the impedemends and risks involved in jatropha cultivation pertainig to the farming community. We dwell upon the responses of the farming community and the scientific community against the backdrop of global promotinal claims and oft-excluded narratives of biofuel adoption. We identify three types of biofuel network, namely, governemnt-led, research-led and private companies and NGO-led respectively in the states of Chhattisgarh, Madhya Pradesh and Rajasthan.

The analysis focuses on the two types of rural users involved in the cultivation of jatropha. It reveals the varying cultural associations, practices, and tacit meanings among the users in each site, and how they associate with the rural development initiatives. It further reveals how the rural users across the three states form different types of linkages with the actors in their networks and how the NMB and the cultivation of jatropha are associated with varying interpretations. The discussion highlights a few issues. It focuses on the low yield rates of jatropha attributed to a lack of research on the appropriate genotypes and highlights how the users were/are not aware of the pruning practices. The

study points out that jatropha is not resistant to pests and also the yield rates are dismal without inputs of irrigation and fertilisers.

The discussion on conflicting narratives captures the importance of narratives in policymaking and how they are used by policymakers to simplify complex development problems which often lead to blueprint development. We reflect upon the national and local narratives supporting the development of biofuels and how these narratives played an important role in the emergence of local biofuel narratives across different states and in turn encouraged the hasty creation of biofuel policies, mandates and missions. The study highlights how the national biodiesel narratives while being influenced by the global narratives displayed regional characteristics specific to India's goals to produce biodiesel. It focuses on the creation of pro-poor, pro-wasteland, and pro-jatropha narratives that supported the introduction of biodiesel production in India. We argue that policymakers, bureaucrats and technocrats use narratives to promote development policies without checking the accuracy of these narratives. Often are narratives based on shaky facts and data that the biodiesel narratives in India are not backed by reliable data. Additionally, the biodiesel narratives misrepresent the needs of the rural poor by labelling their common lands as wastelands. Our argument is supported by the fact that science or technology or technoscience tends to lose its value-neutrality or objectivity under certain social, economic or political circumstances.

In sharp contrast to the states' identification and categorisation of 'wasteland', the rural users proclaim that the land termed as 'wastelands' by the Government of India are not wastelands, but are used as pasture lands to grow woody crops to serve as fuel wood, are the means of procuring revenue by the landless farmers and labourers and are intrinsically linked to communities' livelihoods. As Scott (1998) argues, the state transforms social and natural landscapes through projects of administrative reordering whether through censuses or surveys, monocropping, scientific farming or forestry. The wasteland narrative promoted by the policymakers, bureaucrats and private companies varies from the representation of the rural farmers and labourers, who are unwilling to cultivate jatropha on their common property resources. Hence there is an on-going dispute over the use of these so-called wastelands, which the government disregards or does not notice, before the swift decision to allocate them to cultivate jatropha without consulting the rural people whose subsistence depends on them.

Further, the analysis indicates that the progress and outcomes of the NMB and the NPB are represented differently by the various actors involved in the biodiesel network. The government officials and representatives from private companies insist on the viability of the pro-poor narrative of the programmes and thereby actively encourage the plantation. They advocate the wasteland narrative and have allocated these so-called wastelands for the cultivation of jatropha. The Government of India also leased wastelands to the private companies to grow jatropha. While the government officials, policymakers and private companies represent the NMB as a successful initiative, the rural farmers and labourers express in the opposite. They spoke about the unfair contract farming model between the private companies, the diversion of their common lands to grow jatropha, and land grabbing by private companies. They state that the biofuel policies are displacing them from their common land, promoting unfair contracts, and in turn augmenting their financial burden. Hence they feel that the NMB and the NPB are more of an anti-poor initiative rather than a pro-poor one.

The analysis depicts not-so-optimistic experiences of cultivators where jatropha programmes have failed. The reasons differ according to stakeholders' perspectives and range from a lack of community commitment to shaky scientific facts. Being a perennial plant, jatropha is expected to have a long productive life and it is prudent to invest generously in the initial phase so that the plantations remain productive. Rushing ahead with jatropha cultivation on a large scale without proven germplasm and agronomic practices and the understanding of plant performance under different edaphic conditions inevitably leads to disappointment. Here, we argue that agricultural knowledge extension programmes must consider the historical and social environment it operates in. Moreover, we identify a relationship between knowledge (scientific knowledge) and "social order developed" (Knorr-Cetina 1981) by it in the biofuel promotion and extension. The knowledge production culminates in knowledge consumption such as in the case of farming communities engaged in jatropha cultivation.

Although there is reason to be enthusiastic about jatropha's potential as a biodiesel feedstock in India and beyond, there is one rather sobering concern. Despite the fact that jatropha grows abundantly in the wild, it has never really been domesticated, its yield is not predictable, the conditions that best suit its growth are not well defined and the

potential environmental impacts of large-scale cultivation are not understood at all (Fairless 2007). The future of jatropha is dependent on the policies of the government. Jatropha can be worked on certain places, not in every place with marginal profits. Vel (2014) argues, actors in biofuel network such as policymakers, scientists, private companies, etc. have an important role in promoting and managing jatropha projects. Perhaps, these efforts are not attaining the expectations. Therefore, Muys et al. (2014) comment, 'no viable projects depending solely on jatropha are known', yet Nielsen et al. (2013) conclude that from a development perspective jatropha is a hope despite not having many optimistic outcomes.

5.2 Contributions to STS Studies

The aftermath of the World War II taught us how naïve and unsustainable the linear and interactionist models of the relationship between science, technology and society are. Indeed, the World War II became the intellectual and political vantage point of 'development' discourses. The Asian, African and Latin American experiences have negated the Eurocentric model of development guided by the modernization theory. The modernization theory postulates that the less developed countries would eventually catch up with the already developed counties provided the former apes the development pattern of Western capitalism. Based largely on the theoretical premises of structural functionalism, modernization theory conceptualized development as a staged transition from tradition to modernity, to be brought about at the economic level by the operations of the market and foreign investment; at the social level by the adoption of appropriate Western institutions, values, behaviours; and at the political level by the implementation of parliamentary democracy. A product of the Cold War, and motivated by the concern to challenge socialist ideas in the postcolonial world, modernization theory was criticized for its optimism, over-simplification, and ethnocentrism. It was displaced in the late 1960s as the most popular sociological analysis of development by the dependency approach. This was in turn charged with over-simplification and with merely investing the assumptions of the previous orthodoxy. Criticism of these approaches has left the sociology of development as a fragmented field in which various competing and more modest theories jostle for supremacy. In recent years there has been a growing awareness that the nation-state cannot be analyzed in isolation from the international context. The field also has significant and growing overlaps with the sociological debates about globalization and the environment. There has also been a renewed analytic emphasis on

the interdependency and integration among nations, not just in terms of economic processes, but also at the level of culture and ideology. Our experiences in Asia, Africa and Latin America suggest that development does not occur in a linear or hierarchical manner. Development is not merely economically determined but also culturally embedded. If cultures differ, then trajectories of development differ. The concept of 'Third World development' is rooted in specifically Western ideas of technical progress and the accumulation of capital. This leads to development policies which destroy the cultures of non-Western populations. The drive towards global uniformity in cultures, lifestyles and 'mentalities' has been responsible for endemic civil wars, ecological disasters, and the widespread national debt throughout the Third World.

5.2.1 Merton versus Ziman

In the 1990s, the post-world war II consensus on science and the state began to be disintegrated not just in the developed world but most parts of the developing world drawn into the frame of science and development during the decades of decolonization. This disintegration was itself a product of the coevolution of state and science, as well as the mutual transformations engendered by this parallel evolution. These transformations have been studied, analyzed and investigated by sociologists of science in the West, who have identified for us; (a) the transformations in the world of knowledge production and the move from so-called mode 1 to mode 2 knowledge production, and (b) the changes in the ethos of science from Merton's CUDOS (Communism, Universalism, Disinterestedness, Organised Skepticism) to Ziman's PLACE (Proprietary, Local, Authority, Commissioned, Expert) which then marks the emergence of so-called post-academic science.

While the Mertonian norms represent an ideal for academic science, industrial science has always had other priorities. And, as Ziman (2000) is well aware, scientists sponsored by government departments and NGOs are no better placed. Ziman reprises his earlier characterization of such work by five contrasting norms, with the acronym 'PLACE': the results produced are 'Proprietary', and therefore not necessarily communal; researchers concentrate on 'Local', technical problems which may not contribute to general understanding; 'Authority' is vested in a managerial hierarchy, not in the individual researcher; work is 'Commissioned' to solve specific problems, not as a contribution to

knowledge as a whole; and the scientist is valued as an 'Expert' rather than a source of creativity. Ziman argues that the science practised within the contemporary academia is driven as much by PLACE as by CUDOS. He concludes that the resultant hybrid should properly be described as 'post-academic' science.

These internal changes within science are rendered more complex by the organisational transformation at the different sites of knowledge production themselves. As the so-called traditional institutions of higher learning like the university of teaching and research forge new collaborative ties and arrangements with a variety of stakeholders and clients under the pressure of a state that appears to be withdrawing as the major supporter and sometimes only supporter of scientific research, it has become increasingly important to relook at the contract between the state and science. This is not to say that these are two different domains and the state and society too have been significantly transformed by the advancing frontiers of technology. In fact, the state's relationship with the world of science, and the internal dynamic of scientific and technological evolution has rendered the field of investigation that one might tentatively call the relationship between science and the state highly problematic and contested.

5.2.2 Kuhn's Consensus and Subsequent Paradigm-bound Community

Prior to Kuhn, understanding of scientific practices was confined to the dimension where only scientists as a community had the authority over discourses on technoscience. Technoscience as a neutral and apolitical instrument to reflect on the world and nature which is immune from social dimension has attracted sociologists of scientific knowledge for critical reflection. For example, Bloor (1976) emphasises that all knowledge systems including scientific knowledge have political and social attributes, though he stresses on the exclusivity of scientific community over scientific matters, not sociology as an interrogating domain. Kuhn breaks such exclusion of epistemic segregation developed with the turn of modernity. He brings up those moments of history in scientific discoveries which have had shaped, reshaped and debunked our perceptions to understand the world. In order to do that he explains 'consensus' among scientific community which was contingent upon socio-political factors of that time of history. Consensus – a decision making exercise emerges against the backdrop of social transactions among the state, artefacts, and communities – concretises the norms and practices for a change that is for a new paradigm. In the present study we make an attempt

to capture those instances where on the one hand the scientific community appears to abide by the paradigm in general and by the institutional mandates and the motives of the state in particular; on the other, there is a plurality of scientific practices over the promotion, adoption, research and development of biofuels in India.

5.3 Limitations of the Study

During the first phase of the NMB, biodiesel production was actively taken up by many state governments and it is beyond the scope of this research to carry out the fieldwork and collect data from all the states involved. The present study is limited to public research institutions, central and state universities including state agriculture universities, and state biofuels authorities. Though a few private research institutions and industries were contacted we could not get their assent to collect data. Most important limitation of the study is the absence of participation of bureaucrats those who were/are engaged in policy framing of biofuels in India. This study might have arrived at wider conclusions and gained better insights to understand the politics of biofuels in India had their responses would have been incorporated.

5.4 Scope for Further Research

With increasing interests on renewable energy resources and to follow the global demand-pattern of biofuels, the nature of bioenergy and scope for alternative feedstocks are expanding. Following the global trend, the Government of India has recently (2019) launched a new biofuel policy. Salient features of the National Policy on Biofuels 2018 indicate the inclusion of different feedstocks other than jatropha. Interestingly, the policy emphasises on the use of surplus food crops for biofuels, which was prohibited in the previous policies. Perhaps such policy moves will alter the dynamics of existing biofuels networks. It may open the spaces for a new set of agrarian questions, politics of funding, institutional mandates, and the relationship between state, industry and other stakeholders of biofuels network. This changing trajectory of renewable energy in India pushes towards enquiries which can be persuaded further.

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Annexure I

General Questions Pertaining to Jatropha Cultivation

1. From whom did you hear about Jatropha?
2. Why are you cultivating Jatropha?
3. From where did you get the seeds?
4. What is the method of distribution/purchase of the seeds/saplings from the state agencies or NGOs?
5. What is the cost of seeds?
6. On what quality of soil is Jatropha being cultivated?
7. What are the irrigation/fertiliser requirements?
8. Are there any NGOs / Government Agencies / Private bodies involved?
9. What is the yield till now?
10. What are your expectations from this crop?
11. Have you received any benefits – if any what are they?
12. Are you able to market the goods?
13. Have you had any problems/experiences – good or bad till now?
14. Why do the farmers leasing their land and opt for daily wages at other farms engaged in cash crops?
15. Why is the scenario/opportunity at one block not same as other plantations (such as Godhi/Pendra or in Chhattisgarh/Rajasthan)?

Interview Schedule

1. According to you what is land-management and would you kindly dwell upon the various methods employed for land management/improvement?
2. How do you locate the plantation of trees as a practice in the purview of land-management?
3. Would you kindly dwell upon the factors which assist you to locate the spaces for land-management and among these what are the geographical factors which set the limit/constraint?
4. What are the characteristics that you examine in a plant for the purpose of land-management and would you please elaborate on few of these plants?
5. Would you kindly elaborate on the various sources available in the realm of plant biotechnology to be considered as fuel?
6. Why was preference given to jatropha for plantation over other potential plants?
7. How do you locate the trajectory of jatropha, which is now viewed as a fuel crop from a bush of semi-arid region?
8. How did jatropha come into practice for plantation of fuel crop?
9. Would you kindly reflect upon the conditions that induced the need for new energy sources particularly from plants? (Conventional and fuel for engines)
10. What is the nature of research/extension grant(s) available for the plant improvement? (Are they public/private funded and national/international, or both?)

11. Have you been engaged in collaboration with industry? What is the role of industry in providing assistance for research/research grant, and industrial/commercial application of produce from the crop?
12. What are the complexities involved in the further development of jatropha that you expect from an energy crop?
13. How do you respond to such complexities? Would you kindly furnish a few details based on your experiences?
14. What is the mechanism of blending of biofuels? Is the practice constrained by technological factors or commercial factors?
15. What is your opinion about suitability of biofuels (jatropha) as renewable source of energy and how do you link its renewability vis-à-vis sustainability for producer (farming community)?
16. Do you consider commodity profile of the farming community while promoting the plantation of jatropha?
17. To what extent, according to you, recommendations offered by scientific community are diffused in the farming practices?
18. According to you, what are the socio-political dimensions (farming community/science policy) of getting a grant for research in biofuels?
19. Would you kindly reflect upon the initiatives/policies of the state *after* the commencement of NPB (National Mission on Biodiesel) and what are the characteristics that distinguish them from NPB? (viz. research grant, blending composition, tax incentive, subsidy, etc.)
20. Would you kindly dwell upon the controversies about the biofuels by paying special attention to the case of India?
21. Do you find any link between debates surrounding GMO and biofuels, or debates surrounding these two are mutually independent?
22. What were the factors that encouraged research on biodiesel a decade earlier and inhibited it later?
23. Based on this discussion, can India have an independent NPB policy, and as a corollary an independent science and technology policy?