# Sciences and Cultures: Pluralist Narratives of Biofuels in India

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## 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.

## Review of Literature

### 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).

### 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.

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.

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.

**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.

**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).

**'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.

**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.

**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.

**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.

**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'.

**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.

**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?

**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.

**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.

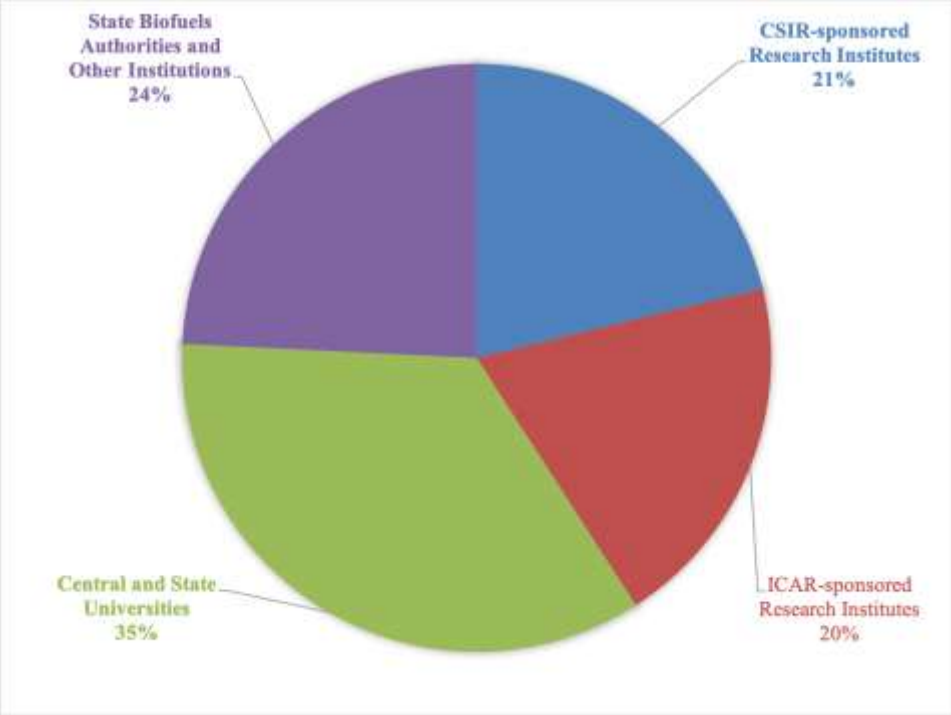
The majority of the data are generated in semi-natural settings by interacting / interviewing with the scientists and the government officials at their laboratory or office. The data is collected through semi-structured in-depth interviews with sixty six scientists and government officials from Indian 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.

**Table I: 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 I: 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. 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 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. 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. Indeed, there have been attempts of biopiracy to get jatropha's germplasm by the foreign oil companies[1]. 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*[2] or jatropha – the state-sponsored names, and it has been in use for various

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

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

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.

**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. 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.

**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. 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[3], 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.

**Structure of the study**

The thesis is arranged in terms of five chapters, and these are as follows:

**Chapter I:** Introduction

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

**Chapter III:** Contestation – Consensus – Contestation in Scientific Claim-making: Sociotechnical Systems for Biofuels in India

**Chapter IV:** Narrating the Cultures and Sciences of Biofuels Production in India

**Chapter VI:** Conclusion

**Chapter I: Introduction**

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.

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

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

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 attempt 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.

**Introducing Biofuels— Global and Indian Experiences**

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.

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).

The Government of India followed the global trend for energy demand and launched the National Mission on Biodiesel in 2003 to produce biofuels domestically. 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. 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.).

**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) 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.

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. Richard Drayton (2000) 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. 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.

There is continuity between colonial and post-colonial land and forest management policies. 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. 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 the NMB erstwhile 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.

**Land Management, Emergence of a Biofuel Crop and Generation of Biofuel Network in India**

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).

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) 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.

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

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.

**The Materiality and Agency of Jatropha**

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). Latour's reflection 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.

**Dialectic of Resistance and Accommodation**

The characteristics of material agency are never decisively known in advance (Pickering 1992). 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.

**Domesticating Jatropha and Shifting Mandates: Dilemma of the Scientific Community**

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.

**Discursive Flexibility of Jatropha**

Borras et al. (2016) refer to 'flex crops,' 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 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". 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. 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.

**Chapter IV: Narrating the Cultures and Sciences of Biofuels Production in India**

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.

**Local Narratives and Enrolment of Users for the Technology**

The jatropha value chain consists of various activities which can be broadly categorised into four categories—farm production of seeds, marketing of seeds, biodiesel production, and biodiesel distribution. The biodiesel production value chain encompassed 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 research sites two classes of users were 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 exhibited different cultural practices and usage patterns. The farmers had the choice to decide what to grow on their land, while the landless labourers did or did not have a choice depending on the research area.

Most of the farmers interviewed across the research sites were marginal farmers owning less than one hectare of land. Based on the state and the people being interviewed there was a difference in opinion on jatropha and farming practices. 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 initial questions we asked were, from whom or how did they hear about jatropha? The farmers said they were approached by government officials, NGO personnel, and representatives of private companies *"…they came and told us about Ratanjyot (Jatropha). They told us that this seed is very beneficial and grows on dry areas and even with little water the yield is good."*

The participants said they primarily heard about jatropha from the *sahaabs* 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, the culture and practices varied across the sites and had an effect on how each set of farmers adopted jatropha plantation.

The analysis of the local narratives supporting the production of biofuels in India advances Keeley and Scoones (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 Raman Singh (the Chief Minister of Chhattisgarh) during a demonstration of a bio-diesel 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).

During most of the conversation when participants were asked about jatropha and what they thought about it, it was observed that different people associated different meanings with the crop. In some villages, the *Sarpanch* associated jatropha with money, subsidies, prosperity; while the labourers cultivating it on common property resources (CPRs) considered it a bane, waste of time, and associated it with subjugation by the government. These discussions revealed how the Sarpanch who was paid money or approached by the government officials said only good things about Jatropha while those who were forced to cultivate it had different ideas about it. A few farmers associated jatropha with money and an opportunity to buy new stoves, clothes, small-scale farmers associated it with extra income, and some villagers associated it with energy to run their pumps.

**Modes of Jatropha Cultivation**

The most commonly observed mode was the farmer centric one, where the farmer owned land and was provided seeds at reduced costs from the government. The farmers planted jatropha and could sell their harvest to whoever they wanted. The second mode

involved plantations on government land managed by rural communities. The government land classified as wastelands encompassed Common Property Resources (CPRs); land which was used by communities for cultivation of crops, and grazing of livestock. In the second mode the government land was managed by Joint Forest Management Committees or other government agencies along with Self Help Groups (SHGs). The various government agencies like sate biofuels boards, forest departments, National Oilseeds and Vegetable Oils Development Board (NOVOD), etc. were key players in this model. They had to ensure that the farmers were provided free seedlings, trained on pruning and plant maintenance, provided fertilisers and manure, and informed about buyback mechanisms. In this mode the farmers were either landless farmers, or landless labourers who were hired to work on the land. The majority of the labourers were placed under the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGA) which guarantees hundred days of wage-employment to rural household members. Many NGOs and SHGs were also involved in this mode. Here the harvest belonged to the government agencies.

The third mode followed a different approach, it was the corporate model of cultivation. It was business oriented as it was managed by private firms both local and international. In this mode the companies either bought or leased vast tracts of land and employed farmers or labourers to plant jatropha, or they formed contracts with farmers or local communities to grow jatropha on their own land. In the contract farming model the company would provide the farmers with cheap seeds or loans and they promised to buy back the seeds at a fixed price. The proportion or majority of models followed, varied across the research sites based on the nature of rural users and practices.

**Nature of Engagement with the Plantation**

The NPB was promoted as a rural development programme 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 overall aim of the programme is: 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, and to strengthen the livelihood resource base, boost the rural economy and to enhance the capacity of the villages to sustain themselves. The

policymakers and government officials said that the cultivation of jatropha would fit the objectives of land development, creation of employment, and durable assets under the MGNREGA. It would also provide labour opportunities for the landless and if they were enrolled under the MGNREGA scheme they would receive wages for their labour irrespective of the output, in this way they did not have to undertake contract farming and neither did they have to invest any money. Based on the guidelines of the MGNREGA many states especially Chhattisgarh, actively invested in jatropha plantation and received funds from the central government. The biofuel development narrative along with targeting creation of employment also emphasised reviving the agricultural sector. Among the solutions which have been proposed, the diversification to 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 NMB and the NPB was 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. Initially many of the interviewees especially government officials said the presence of these companies was good as they would 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 Plc, Mission Biofuels, Emami, Reliance Ltd. did indeed invest actively and according to many interviewees these companies followed a strategy referred as ‘the closed loop mechanism’. According to this the companies entered in to 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 was evident that if the

biodiesel blending standards were implemented across the country there would be a steady demand for jatropha seeds and new plantations. Hence small-scale farmers who grew leguminous crops could also grow jatropha on their land and while they were getting returns from their staple crop they could get extra income from harvesting jatropha seeds.

The main role of D1 Oils was to provide finances for the contract while the role of Mohan Breweries was to convince the people to enter the agreement and ensure they delivered the final product. Local staffs were entrusted with the task of informing the farmers about the NPB, jatropha, and benefits of cultivating it. The farmers and labourers interviewed said that officials from the company regularly visited the villages where jatropha was being cultivated by farmers who had contracts with them. Their visits were to check on the plantations and also to persuade more farmers to form contracts with them. Narottam Sone, A farmer who was initially reluctant to grow jatropha, said "*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".*

**Implications of Jatropha Cultivation for the Farming Community**

The plantations are carried out on land identified by the state government as wasteland. However, the people living in these villages claimed "*it was their land and they had been using it for years and all of the sudden the government decided to use the land for something else*". The villagers were told by officials from the CBDA that they did not have to irrigate the plant, all they had to do was harvest the seeds after three years. The rural users said the prospect of earning money form the harvesting process reassured the villagers to an extent and despite their dissatisfaction with the new initiative they did not protest too much. They said 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 said what the officials told them. He states,

> 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 had not been informed about the importance of pruning and how the failure to do would drastically affect the rate of yield. The state officials and members from CBDA had not anticipated the knowledge gap of the rural farmers and labourers in 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.

Scott (1998) argues that the process of classifying land as wastelands is an example of state simplification. 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 NPB are one such process that altered the relationship between the people and the government when their CPRs were termed as wastelands and diverted for the cultivation of jatropha.

The rural users said the land termed as 'wastelands' by the GoI 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. The wasteland narrative promoted by the policymakers, bureaucrats and private companies varied from the representations of the rural farmers and labourers, who were unwilling to cultivate jatropha on their CPRs. Hence there is an on-going dispute over the use of these so-called wastelands, which the government had disregarded or not taken into notice, before the swift decision to allocate them to cultivate jatropha without consulting the rural people whose subsistence depends on them.

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 said 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. From the interviews with the farmers it emerged, 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.

The rural population comprising landless labourers and marginal farmers were told that they could not use the CPRs for grazing or cultivating subsistence crops, instead they had to grow jatropha on it. The widespread diversion of CPRs for the cultivation of jatropha led to disputes and displacement of farmers, especially in Chhattisgarh, where the officials were keen to implement jatropha plantations. Despite protests from the people, the state government continued with the plantations. During fieldwork, it was clear many of the farmers and labourers were upset with their land being used for jatropha plantation. In a village, the forest officials asked the people to stop using the land for grazing and asked them to cultivate jatropha. Along with being promoted as a non-edible crop, requiring minimal care and inputs, jatropha was also supported because it was toxic and animals did not feed on it, hence prevention was not taken to prevent animals from grazing. The participants said after six months when the saplings had grown cattle trampled upon the plantation and all the saplings perished. The farmers were asked to sow new jatropha seeds and were told to erect a fence.

**Chapter V: Conclusions**

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.

The aim of this 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 not possible to abandon the persuasion of technologies as policy instruments for the developments. Therefore, the study dwells upon the role of the state and other public sector institutes as a promoter of biofuel technology and dissemination of the same as a sustainable source of energy. Findings of the study are based on responses of the farming and scientific communities. Recent studies have depicted not-so-optimistic experiences of cultivators where jatropha programmes have failed. The reasons differ according to stakeholders' perspectives and range from 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 without understanding of plant performance under different edaphic conditions, will inevitably lead to future disappointment.

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 present study 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 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.

The discussion on conflicting narratives emphasised the importance of narratives in policymaking and how they are used by policymakers to simplify complex development problems and often lead to blueprint development. We listed the global narratives supporting the development of biofuels and how these narratives played an important part in the emergence of local biofuel narratives across different countries 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 narratives are based on shaky facts and data, the discussion proves that the biodiesel narratives in India were not backed by reliable data and statistics. Additionally, the biodiesel narratives misrepresented the needs of the rural poor by labelling their common lands as wastelands.

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 associated with the rural development initiative. It further reveals how the rural users across the three states formed different types of linkages with the actors in their networks and how the NMB and the cultivation of jatropha were associated with varying interpretations.

**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.

**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

### 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?

**Academic engagements:**
**Journal Paper:**

- Shukla, R. and Mallick, S. 2020. (Special Article Section) Consensus through contestations? Jatropha in pursuit of biofuels production in India. *Economic and Political Weekly*. Sameeksha Trust (forthcoming)
- Shukla, R. and Mallick, S. 2015. Mechanization of Agriculture: Implications for the Farming Community in India. *Perspectives on Global Development and Technology*, *14*(4): 430-447.

**Paper in Edited Volumes:**

- Shukla, R. and Mallick, S. 2017. 'Blending of practices: a study of selected biofuels complex in India' in S. Suresh, A. Kumar, A. Shukla, R. Singh and C. Krishna (eds.): *Biofuels and Bioenergy* (229-39). Springer Proceedings in Energy, Springer, Cham.

**Conference Proceeding:**

- Shukla, R. and Mallick, S. 2016. Construction of a sustainable energy source: the case of jatropha in Indian context. *Technologies for Development: From Innovation to Social Impact*. EPFL, Lausanne https://cooperation.epfl.ch/files/content/sites/cooperation/files/Tech4Dev%202016/1200-Shukla-SE10- ENE_Full%20Paper.pdf

**Conferences:**

- Shukla, R. and Mallick, S. 'Withering away of the consensus through contestations: Jatropha in pursuit of biofuels production in India'. *Workshop on Interrogating the Emerging Techno-scientific Consensus: Intersections between Citizen Science, STS and Innovation Studies*, Indian Institute of Technology Bombay, December 4, 2018 (travel grant sponsored by Concordia University, Montreal, Canada)
- Shukla, R. 'Conflicting institutional mandates: a study of biofuels production in India'. *National Seminar on Contemporary Debates on Science, Technology and Nationalism in India*, Indian Institute of Technology Guwahati, October 31-November 2, 2018
- Shukla, R. and Mallick, S. 'Assessing the contestation in biofuel production approaches in India'. *43rd Annual Conference of Society for Social Studies of Science (4S)*, Sydney, Australia, August 29 - September 01, 2018 (travel grant sponsored by 4S)
- Shukla, R. 'Sustainable and socio-technological systems in biofuels production in India'. *19th International Sociological Association World Congress of Sociology*, Toronto, Canada, July 15-21, 2018 (in-absentia)
- Shukla, R. 'Questioning sustainability of jatropha plantation: changing agricultural practices in central India'. *43rd All India Sociological Conference*, Lucknow University, Lucknow, November 09-12, 2017
- Shukla, R. 'Sustainable and socio-technological systems in biofuels production in central India'. *4th International Conference on Poverty and Sustainable Development*, Colombo, Sri Lanka, December 05-06, 2017 (fully sponsored by IIT Guwahati)
- Shukla, R. and Mallick, S. 'Narrating the cultures and sciences in biofuels production in India'. *International Conference on Agriculture and Human*

*Development in India: Indigenous Practices, Scientific Views and Sustainability*, Indian Institute of Technology Guwahati, September 08-09, 2017

- Shukla, R. and Mallick, S. 'Cultures, sciences and material agencies: A study of biofuels in India'. *National Conference on Science, Technology and Society*, National Institute of Science Education and Research Bhubaneswar, July 22-23, 2017
- Shukla, R. and Mallick, S. '"Construction" of a sustainable energy source: the case of jatropha in Indian context'. *4th International UNESCO Conference on Technologies for Development: From Innovation to Social Impact*, EPFL, Lausanne, Switzerland, May 02-04, 2016 (fully sponsored by EPFL and UNESCO)
- Shukla, R. and Mallick, S. **'**Blending of practices: a study of selected biofuels complex in India'. *International Conference and Exhibition on Biofuels and Bioenergy*, Maulana Azad National Institute of Technology, Bhopal, India, February 23-25, 2016 (fully sponsored by IIT Guwahati)

**Workshops:**

- The Indialics Training Workshop 2017 (Indialics Academy) on Innovation for Sustainable Development: Perspectives, Policies and Practices in South Asia, Jawaharlal Nehru University, New Delhi, November 1-5, 2017 (travel grant sponsored by JNU, New Delhi)
- ICSSR- Sponsered Ten-Day Research Methodology Programme for PhD Students in Social Sciences, Indian Institute of Technology Guwahati, March 14-23, 2016