“Construction” of a Sustainable Energy Source: the Case of Jatropha in Indian Context

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Abstract: Biofuels have caught the attention of the world as a source of renewable energy which can provide energy security, advance rural development, mitigate climate change, and foster international trade. India developed the National Mission on Biodiesel (NMB) as a rural development policy option to produce biodiesel from Jatropha and promoted it as a pro-poor and pro-growth initiative. The study will attempt to examine the emergence, trajectory, and the consequences of the NMB by examining the case of a public sector research institute involvement in developing and disseminating the technologies for sustainable energy in India. The study will also locate 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? And, where does new cultivation get (the) space? These research questions will be examined within the theoretical framework of Science and Technology Studies (STS); where social, political, economic, cultural, institutional, ideological, etc. factors will account for production of knowledge, its accessibility, and application. To address the research objectives both primary and secondary sources has been used. The primary data is obtained by deploying in-depth interviews of the scientific community and the sources of secondary data viz. academic journals, books, policy documents.

Keywords: Biofuels, Energy, Agriculture, Jatropha, India

Full Paper

Introduction, Objectives and Methodology of the Study

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 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 was in the decade of 1970-1980 when the several nations were in midst of the cold war. This lead to oil embargo, question of national security and emergence of environmental problems created the situation for the search for alternative fuels (Kovarik 1998). From the projected levels of energy demand and available resources it is increasingly apparent that new sources of science and technology should be tapped to meet the ever increasing demand for energy. Among the varying options being explored, biofuels have emerged as a viable option. The term biofuel refers to energy produced from biomass through processes such as solid combustion, gasification or fermentation (Demirbas 2009). Biofuels are liquid fuels produced from ‘renewable resources’; they are mainly derived from organic matter and are a versatile source of energy. Biofuels have gained popularity as a global solution due to their potential to “reshape livelihoods, patterns of resource consumption, environments and agro-food production systems” (Smith 2010).

India was among the countries who were advocating biofuels programmes, missions, and policies. Government of India (GoI) has been promoting renewable sources of energy production since 2002 and the National Mission on Biodiesel (NMB) aligned with the aims of the government to promote green sources of energy production. The NMB was publicised by the GoI as a development initiative and the objective of introducing a new technology/initiative was portrayed as an environmentally friendly method of producing energy domestically, in the process generating rural employment, improving the agriculture sector, and reducing oil imports (GoI 2003). It aimed at producing biodiesel from *Jatropha Curcas* (hereafter Jatropha), a non-edible oil seed, which would be cultivated on land under the scheme of Joint Forestry Management, hedges around agricultural land, 'culturable fallow lands', stretches of public land along railway tracks, highways, canals, and dry and marginal 'wastelands' (ibid.).

In this vein, the study concentrates on scientific practices employed for the construction of a biofuels plant and their impact on development discourse of an emerging economy—India. Specifically, the present study goes on to present the responses of scientific community of Council of Scientific & Industrial Research (CSIR) sponsored research institute namely Central Salt & Marine Chemicals Research Institute (CSMCRI)—Bhavnagar, India. The rationale for selection of the field site lies in the fact that CSMCRI has been engaged in research and development of renewable energy technologies, especially production of biodiesel from Jatropha. It is imperative to discuss the case of a public sector research institute involvement in developing and disseminating the technologies for sustainable energy in India. The objectives of this study are to:

a) Understand the emergence of Jatropha as a source of 'sustainable' energy and its ability to grow on 'wastelands', and to locate its trajectory in the process of enrollment in biofuels network.
b) Understand how biofuels have been popularised in India with manifold social benefits and to analyse the underlying assumption in discourses of scientific claim-making in promotion of biofuels in India.

The methodology adopted to achieve objectives of the study is qualitative in nature. In-depth interviews have been conducted with scientists and engineers engaged in research and development of the sustainable energy sources at CSMCRI, especially in the field of biofuel production from Jatropha. The discussion is based upon the transcript obtained after the in-depth interviews. Content analysis has been deployed to examine information generated through secondary sources, including policy documents on biofuels, literature on science and technology studies, books and academic journals.The interview schedule broadly covered the following aspects of the study:

a) The response of the scientific community in the issue of land-management
b) The emergence of need for biofuels and construction of Jatropha as a source of sustainable energy source
c) The response of the scientific community in the process of development of the variety and complexities they encountered
d) The perception of stakeholders about the methods of the cultivation
e) The role of the public research institution(s) vis-à-vis private institutions in the research and development of biofuels in India

Observations: Responses of the Scientific Community and Potential Development Impacts

The following discussion will cover the responses of the scientific community over the adoption of Jatropha as biofuels crop. Furthermore, we shall discuss the emergence of the crop from a practice of land management to a potential source of biofuels. Here we will 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. Then we go on to explore the various practices emerged in the midst of development narratives attached to Jatropha.

Initially Jatropha was adopted as a crop for 'improvement' of land by a research institute supported by the Indian state. Western part of India with lesser rainfall has very less intensity of vegetation and researches were trying to 'improve' the condition of landscape by adopting some measures. These measures were searching for the plant with specific characteristics which could sustain in semi-arid region with low water requirement; that could withhold soil from erosion; able to improve the nutrients level of soil; and have a considerable life span. This searching task was executed by Council of Scientific and Industrial Research (CSIR) sponsored Central Salt and Marine Chemicals Research Institute (CSMCRI)—Bhavnagar, India. Scientists in CSMCRI refer land management as:

> … [Land management] is about selection of wasteland. There are various kinds of wasteland viz. saline wasteland, rocky wasteland, water-logged land, frosty land etc. Any sort of land with inherent problem or limitations where normal arable crop can not be grown.

Another respondent has the similar views on wasteland and an emphasis for plantation:

> We are targeting on the wastelands where nothing else grows. Jatropha has the capacity to grow in such lands, provided the soil is amended well before the plantation. A deep digging is required through heavy machinery once in a life-time. It will not bear expected quantity of fruits if no soil work will be done. Essential requirement is how to manage the root-zone.

The scientists identified Jatropha and Pongamia having the characteristics to grow in wasteland and simultaneously improve the land. Later, Jatropha planted in Gujrat—Western India, and Odisha—Eastern India with the funding of United Nations Development Programe (UNDP) in 1996. The results of plantation were optimistic for future coverage on other part of semi-arid regions of India. Meanwhile, some State governments, oil marketing companies and research organizations started taking the interest in Jatropha promotion. Daimler-Chrysler used the oil in Mercedes Benz and ran about 10000 km and was satisfied with engine performance; D1 oil, a UK oil firm, collaborated with CSMCRI and the government of Chattisgarh for oil processing and distribution, and various other State governments proposed enthusiastic plans for the plantation, promotion, and distribution. CSMCRI received the funds from UNDP to cultivate Jatropha at modest scale. But, the intention of plantation was not for biofuels, rather to 'improve' coastal areas, sand dunes and 'waste lands'. Later it was followed by appropriation of land after the improvement. Nonetheless, the fact that Jatropha lived up to its reputation as a shrub that could eke out a living on relatively 'barren' land piqued the interest of India's Department of Biotechnology, which provided a modest funding for further exploration of biofuels possibilities using cuttings from three of the most productive plants in the UNDP trial. 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).

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 among these 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" (ibid, 7). The fruits of Jatropha contain considerable quantity of oil but poisonous in nature for consumption by animals and humans. Though, industrial requirement for soap production and burning at domestic level have been the applications of Jatropha oil since a long time in India. It has long been used around the world as a source of lamp oil and soap, and as a hedging plant (Kovarik 1998). Scientists were aware of such property of Jatropha but oil extraction as a fuel for engines was not in their agenda at time of plantation for landscape development in India.

By the time Jatropha had been established as a renewable source of energy and as an instrument with manifold societal benefits. It was projected as hardy crop which doesn't require soil management, irrigation, fertilizers, and it is resistant to diseases. But, after the plantation it was observed that the plants survived without water and nutrients but could not bear fruits or had in lesser quantity than expected. The plants were also easily susceptible to various diseases as well viz. fungal, virus infection, pest, insect, etc. According to one of the respondents:

> Main problem with Jatropha is that it is not fully domesticated in our country (India). Though a lot of research has been done for its domestication, but still we do not have many good varieties of the plant. We are lacking in quality material for the plantation. If the seed from some unknown material, just for the purpose of growing somewhere in the fields, then it leads to difficulty in evaluating the performance of particular plant. We do not know how much yield would occur and how the plant would perform; the reason is the seeds are taken from unknown material.

Jatropha is a perennial plant, full cycle of crop does not complete within a year. It is imperative to observe performance of the plant year by year until it reaches in the stable condition. After four to five years of plantation it reaches at maturity level and then only yield from the plant gets stabilized. The scientific community (Ghosh et al. 2007; Singh et al. 2010) emphasizes the need of selected genotypes for the plantation. They argue that plantation with unknown and undomesticated material leads to wastage resources and unexpected yield from the plant. Further they confirms that if the objective is to cover the unproductive area with green, unknown material can be planted; but, before taking the plantation at commercial level genotype of material should be known. It is also necessary that land must be fertile to some extent, to get considerable economic returns.

The constraints encountered by scientific community in development of the varieties are twofold; firstly, location/geographical factor, and secondly the issue of sustainability of the plant. One of the respondents admits that "We do not have any established variety which can perform in all sorts of soil. Unlike crops viz. wheat, rice, corn etc. we have many varieties for various sorts of areas, soil and climate; but, this is not the situation with Jatropha". Hence, so far developed varieties of Jatropha are restricted to specific areas only. The sustainability constraint could be surmounted when the plant can reproduce year after year without use of hybrid seeds; hybrids are limited to one generation only. Varieties are developed after monitoring generation after generation and it may take eight to ten years to develop a variety in case of Jatropha. Research and development is required in area of variety development for Jatropha.

Limitation to the scientific community are not limited to variety development, indeed they encountered resistance from the plant itself. Earlier it was assumed that the plant is resistant to disease, but now in different locations plants are found to be infested with various diseases. The respondent who develops tissue culture for the plant confirms that:

> Whatever we have researched on (the plant), and what we expect from a plant, it should behave consistently whether it is Jatropha or other plant. Basic problem for any plant is disease. Jatropha is also susceptible to different kind of disease viz. fungal collard, viral infection, and insects and pests are also friendly with this plant. Genetic engineering may help to develop some disease resistant germplasm.

On the employment of biotechnology for genetic modification of the plant, either for disease resistance or for the variety development, there is a lack of consensus among the scientists. As we have marked an inclination of the respondent in preceding view for the use of biotechnology, another scientist has apprehension about the same. She responds to the employment of biotechnology as a niche for the development of Jatropha:

> I go with traditional breeding. Science has some limitations. For some disease testing tools are available and for some are not. The introduction of a new gene definitely will work according to its function, but it also changes some function of organ(s) of plant, which can not be detected at the moment and cause some problem in the future. It is problem of jumping genes, they don't behave uniformly.

Aforementioned views, over use of biotechnolgy for the plant, emphasis on risk and uncertainty over politics of policy. Biofuels have been promoted and developed by the policy framers and biotech industry as an allegedly sustainable alternative to fossil fuels. However, during the past decade other actors have voiced their concerns about potentially detrimental social and environmental effects from large-scale biofuel production (White and Dasgupta 2010; Shinoj et al. 2011) . They argue in support of assessment of uncertainties associated with scientific and technological inventions and criticized the just acknowledgement and quantification of risk approach. In the case of Jatropha uncertainity is not centered at use of partucular technology only, although it is spread over the method of plantation and expected yield after the plantation. According to the respondents:

> One should always plant cuttings not the seedlings. The seedlings have genetic variability. If you plant thousand plants, all will behave differently; whereas, the plants from cuttings and tissue culture will yield consistently. Other important point to consider that the cuttings and tissue culture plant should be from known varieties or from known plant of good history. Selection of germplasm is the most important criteria.

A few studies have been conducted on the yield of Jatropha and its economic viability (Ariza-Montobbio et al. 2010; Findlater and Kandlikar 2011 ; Baka 2014). It can be argued that the practices employed by the cultivators were different that resulted into varying yield of seeds. According to a respondent "what people did, they just got the hold of some seeds from forest for the plantation which resulted in no yield at all". The epistemic practices emerging from scientific knowledge and traditional/cultural knowledge system lead to employment of distinct cropping methods. The contrast between "technical rationality" and "cultural rationality" appears in outcome and process of decision-making (Wyne 1988). Former's mindset puts her faith in empirical evidence, logical consistency, universality of findings and follow expert judgment in policy decisions; whereas, latter gives equal emphasis to personal and familiar experiences rather than depersonalized technical calculations, values the opinion of peer group with respect to their social standing and trusts process over outcome. People weigh evidences with their past experience and if there is possibility of deception or manipulation, they decide to go with cultural rationality. The incapability of technical experts to incorporate social factor leads to irrational decision and further in policy making. Universalistic findings of science may not be applicable to local community if those are not combined with socio-cultural perspective (Leach et al. 2005). When the national mission on biodiesel was envisioned, the designers (policy-makers, government officials, scientists) identified the rural users and their roles, however they did not perceive the extensive 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. 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 mission.

A few examples can also be drawn from the collabration between public and private institions, which show their respective interests in promotion of biofuels. Nexus between them resulted into a policy in line with earlier biotechnology policy to boost implementation of plans and setups for new technology (Scoones 2006). Concessions in acquiring land, tax rebates for start-ups, low or nil tariffs in technology transfers are some examples which show the privileged status of businesses in biofuels. A few companies have taken up Jatropha and are developing the quality material for the plantation along with production of biodiesel. Indeed a few among them are providing the seeds to farmers at their own cost. But, these special treatments serve only commercial and political interests of a few; farmers had no voice in policy making so they were not on the pie of profit, rather their livelihood seems to be on stake and possibility of trapping by dependence over multinational organizations. These companies' benevolent approach of dissemination and diffusion of technology raises some question related to sustainability of the crop and dependence of the cultivators. According to one the respondents:

> As far as private companies are concerned they are developing only hybrids. Every year they are developing new hybrids and selling these to cultivators. They have resources and facilities and they can invest every year and develop a hybrid; whereas, In the case of public research institutions they can not invest in developing the hybrids on yearly basis. Our priority is to develop the verities which can be grown at varied location with generational consistency.

Nevertheless, considering the nature of agricultural pursuit in India, it may be observed that new technology enters farm economy through large size holdings. Large holdings have investment potential, capacity to bear risk and reasonable size of holding to afford the use of mechanical power, which is invariably raises the income of the farmers who employ new technologies (Ray 2012). The crop will not be profitable to farmers having small land holdings owing to expensive management. Farmers who are growing other crops and Jatropha as secondary crop can expect good returns. On the other hand the hype created for emergence of millions of rural employment could not withstand with reality. Only some skilled with new technology managed to get employment in laboratories or initiated own business. Knowledge economy in coming years will consume urban and rural workforce, is still an open question (Scoones 2006). Scoones questions the above imaginations of planners by contextualizing the science, politics and policy in new economy of globalized and liberalized world. In doing so he does not subscribe the view of pro-biotechnology or anti-biotechnology. He only raises the questions pertaining to appropriate science and technology policy for India, changing pattern of ownership, control of technology and agriculture produce, participation, poverty, and vision of development. He compares the situations and approaches for green revolution and gene revolution in the era of new economy, new science and new policy. During the green revolution agricultural technology was based on field trials, research and developments activities was funded by state, and scientists and organizations were not concerned on profit making; on the other hand gene revolution intensively depends on laboratory experiments, funding in research and development is done through public-private or private organizations with profit laden motto supported by intellectual property rights regime.

Though there are varied perspectives on adoption of biofuels. A few perspectives focus on adverse consequences of biofuel on ecological cycle; others are in favour of biofuels as a product of biomass at rural level but not for mass production at industrial level (Shiva 2008). And, a few have apprehensions over adoption of biofuels in either situation. 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). That implies the shifting of resources from catering the need at subsistence level to commercial fuel production. 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). The Indian approach to biofuels is different. Where other countries are using food crops for biofuels production and diverting arable land for the production, India thrived for non-edible crop Jatropha at wastelands. Recent research suggests that while Jatropha plant can survive on degraded soil, they can only produce seeds in considerable quantity on fertile soil and with proper care/ crop management. This takes us back to food versus fuel dilemma.

Conclusion and Recommendations

The aim of this study is to locate the trajectory of Jatropha and its construction as a biofuels crop in India. Biofuels as technology 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 has dwelled upon the role of a public sector institute 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 scientists associated with CSMCRI. Key recommendations based on the findings of the study are as follows:

a) Recent studies have depicted some pessimistic 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.
b) More research is required to develop the varieties which can flourish at varied location and have resistance towards disease. Biotechnology may help to develop some disease resistant germplasm and advances are already being reported. Scientists are trying to develop genetic markers for conventional breeding and molecular plant breeding. Unless more research takes care of disease and pests problem, it is not advisable to cultivate the genetically modified Jatropha. Indeed, other round of preliminary support is required in order to plant at commercial level.
c) It could be attributed from the perspective of the scientific community that lack of proper agronomic understanding of the cultivators and exaggerated claims of productivity lead to inevitable backlash when reality failed to match expectations. Therefore, focus should be on primary data so that information can be responsibly disseminated.
d) Cultivators and policy-makers must also be suitably educated on soil and weather conditions that must be avoided for the plantation. Jatropha is currently not suitable for saline, alkali soil, frosty soil, waterlogged conditions, and it is not frost tolerant. At the same time, research must be intensified both to improve yield and to make the plant more robust. This will open up further avenues for Jatropha cultivation. It is hoped that productivity will improve substantially in the future through inputs from biotechnology.
e) While individual farmers with small land holding can cultivate in small patches of land; whereas the plant can be set up as part of a cooperative for the farming community with marginal land holding. The plantation takes four to five years to get into full bloom state. If the farming community adopts it, break-even is not achievable before seven to eight years. Some state support should be there for this period to encourage the cultivators.
f) It has been discussed in the previous section that there is a gap in dissemination of technology from laboratory to field. The conflict between scientific knowledge system and cultural practices of cultivators resulted in to varying and unexpected yield of the seed. Integration of knowledge system and better understanding of others' perspective may reduce the conflict.

In this backdrop the emergence of biofuels particularly Jatropha as a fuel can be conceptualized within the definition of fuel where "fuel is a […] peculiar technology nothing is inherently fuel. Fuel is simply a term for carrier of energy" (Carolan 2009, 422). The presence of socio-technological system at that time identified Jatropha as a carrier of energy and then it came into the ambit of fuel. Jatropha—or biofuels per say—as new carrier of energy compared and contested with fossil fuels irrespective of efficiency or other comparable parameters. There was nothing inevitable and natural in emergence of Jatropha as biofuels. It has been in application in rural areas for burning from long time. But, what was distinct in 2002, it was the global and local attributes imparted by socio-technical system placed in combination of state, research organizations, development and funding organizations, automobile sectors, and oil sectors. It does not imply that there no resistance were observed, rather initial oppositions were also emanating from same socio-technical system.

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