BIOFUELS

K.S. Kavi Kumar

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Preface

This bibliographical survey focuses on studies related to social, economic and environmental issues associated with biofuels. Biofuels have gained prominence worldwide in the backdrop of growing energy security concerns and increasing greenhouse gas emissions. The adoption of biofuel cultivation however also led to concerns regarding rising food prices and adverse livelihood effects. Studies covering both national and international experiences are included in the survey. The broad areas covered include: potential of first and second generation biofuels, food versus fuel debate, sustainable use of biofuels, and biofuel policies.

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BIBLIOGRAPHICAL SURVEY

Acosta-Michlik, L., W. Lucht, A. Bondeau, and T. Beringer (2011), "Integrated Assessment of Sustainability Trade-offs and Pathways for Global Bioenergy Production: Framing a Novel Hybrid Approach", *Renewable and Sustainable Energy Reviews*, 15, 2791-2809.

This paper frames a novel hybrid approach for assessing bioenergy potentials for regions with diverging economic, social and ecological systems. The approach is based on a conceptual framework that takes into account trade-offs decisions on sustainability goals and production options in the assessment of bioenergy pathways. It combines different empirical techniques for the systematic investigation of trade-offs and pathways including fuzzy logic, conjoint, logit, and path analyses. The paper further illustrates the application of the techniques using results and data from previous related studies.

Akhurst, M., N. Kalas, and J. Woods (2011), "Meta-Analysis of Biomass Potentials for Biofuel Production", *Science Insights for Biofuel Policy*, 2, 1-9.

This paper summarizes the main findings of published research on, (a) lingo-cellulosic crops grown on abandoned/fallow/degraded lands; (b) low input, high diversity grasses grown on marginal grassland, savannah and shrub land; (c) surplus forest products; and (d) farming, forestry and municipal waste and residues. The paper also reviews the economic viability of each option where possible.

Ariza-Montobbio, P. and S. Lele (2010), "Jatropha Plantations for Biodiesel in Tamil Nadu, India: Viability, Livelihood Trade-offs, and Latent Conflicts", *Ecological Economics*, 70 (2):189-195.

Studying the agronomic and economic viability and livelihood impacts of Jatropha curcas plantations on private farms in Tamil Nadu, India, the study found that Jatropha yields are much lower than expected and its cultivation is

currently unviable, and even its potential viability is strongly determined by water access. The study further argues that the water demands of the crop can potentially exacerbate the conflicts and competition over water access in Tamil Nadu villages.

Axelsson, L., M. Franzen, M. Ostwald, G. Berndes, and N.H. Ravindranath (2011), "Performance of Jatropha Biodiesel Production and its Environmental and Socio-Economic Impacts: A Case Study in Southern India", Paper Presented at *World Renewable Energy Congress 2011*, 8-13 May, Linkoping, Sweden.

This paper explores the performance of Jatropha biodiesel production in Southern India in an attempt to identify motivational factors for continued Jatropha cultivation, and to assess environmental and socio-economic impacts of the Jatropha biodiesel production. 106 farmers who have or have had Jatropha plantations were visited and interviewed regarding their opinion of Jatropha cultivation. The results indicates that 85 percent of the farmers have discontinued cultivation of Jatropha. The main barriers to continued cultivation derive from ecological problems, economic losses, and problems in the development and execution of the governmental implementation of the Jatropha programme. The Jatropha characteristics were overrated, and the plantations failed to provide income to the farmer. A common factor for the farmers who continued Jatropha cultivation was that they had the economic means to maintain non-profitable plantations. As the Jatropha programme was not as successful as expected, the expected positive environmental and socio-economic impacts have not been realized.

Basavaraj, G., P. P. Rao, Ch.R. Reddy, A.A. Kumar, P.S. Rao, and B.V.S. Reddy (2012), "A Review of the National Biofuel Policy in India: A Critique of the Need to Promote Alternative Feedstocks", Working Paper 34, International Crops Research Institute for the Semi-Arid Tropics, Patancheru.

This paper highlights the salient features of India's biofuel policy, particularly pertaining to bioethanol, and discusses how it influences the

sustainability and commercialization of ethanol production in the country. The paper also addresses the long-term sustainability of ethanol production from molasses for blending mandates. Finally, the viability of using an alternative feedstock like sweet sorghum that is grown in the drylands for bioethanol production and policy options for its promotion are explored.

Cai, X., X. Zhang, and D. Wang (2011), "Land Availability for Biofuel Production", *Environmental Science and Technology*, 45(1), 334-339.

This paper presents a global estimate of land available for biofuel production based on physical characteristics of land, such as soil productivity, land slope, and climate, using existing global databases, including the remotely sensed land use estimates. The results are presented for regions and countries with major agricultural production capacity or potential, including Africa, China, Europe, India, South America, and the continental United States. On the basis of the land availability for biofuel production, the paper also estimates the net energy gain (NEG) using average NEG per hectare obtained from the literature.

Carriquiry, M., X. Du, and G. R. Timilsina (2010), "Second-Generation Biofuels: Economics and Policies", Policy Research Working Paper 5406, Environment and Energy Team, The World Bank, Washington DC.

This study reviews the economic potential and environmental implications of production of second-generation biofuels from a variety of feedstocks. Although second generation biofuels could significantly contribute to the future energy supply mix, cost is a major barrier to increasing commercial production in the near to medium term. Depending on various factors, the cost of second generation (cellulosic) ethanol can be two to three times as high as the current price of gasoline on an energy equivalent basis. The cost of biodiesel produced from microalgae, a prospective feedstock, is many times higher than the current price of diesel. Policy instruments for increasing biofuels use, such as fiscal incentives, should be based on the relative merits of different types of biofuels.

Carriquiry, M.A., X. Du, G.R. Timilsina (2011), "Second Generation Biofuels: Economics and Policies", *Energy Policy*, 39, 4222-4234.

This study reviews economics of production of second generation biofuels from various feedstocks, including crop and wood/forestry residues, lignocellulosic energy crops, jatropha, and algae. The study indicates that while second generation biofuels could significantly contribute to the future energy supply mix, cost is a major barrier to its commercial production in the near to medium term. Depending upon type of biofuels, feedstock prices and conversion costs, the cost of cellulosic ethanol is found to be two to three times higher than the current price of gasoline on an energy equivalent basis. The median cost (across the studies reviewed) of biodiesel produced from microalgae, a prospective feedstock, is seven times higher than the current price of diesel, although much higher cost estimates have been reported. As compared with the case of first generation biofuels, in which feedstock can account for over two-thirds of the total costs, the share of feedstock in the total costs is relatively lower (30–50%) in the case of second generation biofuels.

Chakaravorty, U., M. Hubert, and L. Nostbakken (2009), "Fuel versus Food", *Annual Review of Resource Economics*, 1, 645-663.

This paper critically reviews the small but growing literature addressing the question, 'to what extent do these trends imply a reallocation of scarce land away from food to fuel production?' The authors find that an increase in biofuel production may have a significant effect on food prices and, in certain parts of the world, in speeding up deforestation through land conversion. The paper also argues that more research needs to be done to examine the effect of newer generation biofuel technologies that are less land intensive as well as the effect of environmental regulation and trade policies on land-use pattern.

Chalmers, J. and G. Archer (2011), "Development of a Sustainability Reporting Scheme for Biofuels: A UK Case Study", *Energy Policy*, 39, 5682-5689.

This paper provides a case study of the development of the regulatory sustainability reporting scheme for biofuels in the UK. The paper argues that the scheme has significantly increased understanding by policy-makers, the biofuel industry and its supply chains on how to monitor and manage the sustainability risks of biofuels and increase their greenhouse gas benefits.

Chanakya, H.N., D. M. Mahapatra, S. Ravi, V.S. Chauhan, and R. Abitha (2012), "Sustainability of Large Scale Algal Biofuel Production in India", *Journal of Indian Institute of Science*, 92, 63-98.

This paper argues that to realize a near complete substitution of the current level of fossil fuels by algal biofuels, a whole lot of decentralized algae harvesting and primary processing infrastructure needs to be set-up to ensure that algal production, processing and resource recycling can occur with low losses and increased sustainability.

Cotula, L., N. Dyer, and S. Vermeulen (2008), "Fuelling Exclusion? The Biofules Boom and Poor People's Access to Land", International Institute for Environment and Development, London.

This study finds that biofuels can be instrumental in bringing an agricultural renaissance that revitalises land use and livelihoods in rural areas. Price signals to small-scale farmers could significantly increase both yields and incomes, securing real, long-term poverty reduction in countries that have a high dependence on agricultural commodities. Large-scale biofuels cultivation could also provide benefits in the form of employment, skills development and secondary industry.

Creutzig, F., E. Corbera, S. Bolwig, and C. Hunsberger (2013), "Integrating Place-specific Livelihood and Equity Outcomes into Global Assessments of Bioenergy Deployment", *Environmental Research Letters*, 8, doi:10.1088/1748-9326/8/3/035047

This paper links human geography research on the interaction between biofuel crops and livelihoods in developing countries to integrated assessments on biofuels. It reviews case-study research focused on first-

generation biofuel crops to demonstrate that food, income, land and other assets such as health are key livelihood dimensions that can be impacted by such crops and we highlight how place-specific and global dynamics influence both aggregate and distributional outcomes across these livelihood dimensions. The paper further argues that place-specific production models and land tenure regimes mediate livelihood outcomes, which are also in turn affected by global and regional markets and their resulting equilibrium dynamics. The place-specific perspective suggests that distributional consequences are a crucial complement to aggregate outcomes; this has not been given enough weight in comprehensive assessments to date. By narrowing the gap between place-specific case studies and global models, the paper offers a route towards integrating livelihood and equity considerations into scenarios of future bioenergy deployment, thus contributing to a key challenge in sustainability sciences.

Das, S., J.A. Priess and C. Schweitzer (2011), "Modelling Regional Scale Biofuel Scenarios – A Case Study for India", *GCB Bioenergy*, doi: 10.1111/j.1757-1707.2011.01114.x

Using integrated modelling framework for simulating land-use change and bioenergy production under two scenarios – industrial economy and agricultural economy, the study suggests that meeting the 20% blending target is a challenging goal to achieve under both scenarios for India.

de Fraiture, C., M. Giordano, and Y. Liao (2008), "Biofuels and Implications for Agricultural Water Use: Blue Impacts of Green Energy", *Water Policy*, 1, 67-81.

This paper explores the land and water implications of increased biofuel production globally and with special focus on these two important countries, using the WATERSIM model. It concludes that, although of lesser concern at the global level, local and regional impact could be substantial. The paper further argues that the strain on water resources would be such in China and India that it is unlikely that policy makers will pursue biofuel options, at least those based on traditional field crops.

Demirbas, A. (2009), "Political, Economic and Environmental Impacts of Biofuels: A Review", *Applied Energy*, 86, S108-S117.

Arguing that biofuel policy aims to promote the use in transport of fuels made from biomass, as well as other renewable fuels, this paper reviews the political, economic and environmental impacts of biofuels.

Diaz-Chavez, R.A. (2011), "Assessing Biofuels: Aiming for Sustainable Development or Complying with the Market?", *Energy Policy*, 39, 5763-5769.

The growing interest in biofuels has led to increasing concern about their wider implications, particularly if grown for transport use in large scale. This paper provides an overview on the sustainability assessment of biofuels to consider a possible way forward.

Doornbosch, R. and R. Steenblik (2007), "Biofuels: Is the Cure Worse than the Disease?", Report No. SG/SD/RT (2007)3/REV1, Round Table on Sustainable Development, Organization for Economic Co-operation and Development, Paris.

Biofuels have been championed as an energy source that can increase security of supply, reduce vehicle emissions and provide a new income stream for farmers. These claims are contested, however. Critics assert that biofuels will increase energy-price volatility, food prices and even life-cycle emissions of greenhouse gases. This paper presents salient facts and figures to shed light on these controversial issues and asks whether biofuels offer a cure that is worse than the disease they seek to heal.

Elbehri, A., A. Segerstedt, and P. Liu (2013), "Biofuels and the Sustainability Challenge: A Global Assessment of Sustainability Issues, Trends and Policies for Biofuels and Related Feedstocks", Trade and Market Division, Food and Agriculture Organization, Rome.

This report addresses the central issue of biofuel sustainability using a global assessment of major commodities and feedstocks currently employed for bioethanol and biodiesel production. The approach taken was guided by two

overriding considerations. First, the need to understand the basic dimensions of sustainability for biofuels (economic, environmental and social), their linkages and how they relate to the central challenges they address, namely land-use change, food security and climate change. Second, the need to critically evaluate the extent to which the recent trends in biofuel certification schemes reflect true sustainability versus trade flow regulation under the guise of sustainability; in other words, are the initiatives essentially market driven or sustainability motivated, or both?

Findlater, K.M. and M. Kandlikar (2011), "Land Use and Second-Generation Biofuel Feedstocks: The Unconsidered Impacts of Jatropha Biodiesel in Rajasthan, India", *Energy Policy*, 39, 3404-3413.

This paper examines the special local impacts of rapid jatropha plantation development on rural livelihoods and land use in Rajasthan, India. The paper reports that in Jhadol Tehsil, jatropha is planted on both government and private land, and has typically displaced grazing and forage collection. For those at the socio-economic margins, these unconsidered impacts counteract the very benefits that the biofuel programs aim to create.

Gahukar, R.T. (2012), "New Sources of Feed Stocks for Biofuels Production: Indian Perspectives", *Journal of Petroleum Technology and Alternative Fuels*, 3(3): 24-28.

Arguing that given the current food insecurity in India, foods crops should be excluded from the list of feed stocks, the paper argues in favour of third generation biofuels that will have environmental, economic and social benefits to communities and reflect energy efficiency.

Gardebroek, C. and M.A. Hernandez (2013), "Do Energy Prices Stimulate Food Price Volatility? Examining Volatility Transmission Between US Oil, Ethanol and Corn Markets", *Energy Economics*, 40, 119-129.

This paper examines volatility transmission in oil, ethanol and corn prices in the United States between 1997 and 2011. The paper follows a multivariate GARCH approach to evaluate the level of interdependence and the dynamics

of volatility across these markets. The estimation results indicate a higher interaction between ethanol and corn markets in recent years, particularly after 2006 when ethanol became the sole alternative oxygenate for gasoline.

Gmunder, S., R. Singh, S. Pfister, A. Adheloya, and R. Zah (2012), "Environmental Impacts of Jatropha Curcas Biodiesel in India", *Journal of Biomedicine and Biotechnology*, doi:10.1155/2012/623070.

This paper presents results concerning the range of environmental impacts of different *Jatropha curcas* cultivation systems. Nine agronomic trials in Andhra Pradesh are analysed, in which the yield was measured as a function of different inputs such as water, fertilizer, pesticides, and arbuscular mycorrhizal fungi. Overall, this study shows that the use of *Jatropha curcas* biodiesel generally reduces the global warming potential and the nonrenewable energy demand as compared to fossil diesel. On the other hand, the environmental impacts increased on acidification, ecotoxicity, eutrophication, and water depletion.

Golub, A.A., B.B. Henderson, T.W. Hertel, P.J. Gerber, S.K. Rose, and B. Sohngen (2013), "Global Climate Policy Impacts on Livestock, Land Use, Livelihoods, and Food Security, "*Proceedings of National Academy of Sciences*, 110(52), 20894-20899.

This paper provides an integrated assessment of the linkages between land-based climate policies, development, and food security, with a particular emphasis on abatement opportunities and impacts in the livestock *sector*.

Gorter, H. and D.R. Just (2010), "The Social Costs and Benefits of Biofuels: The Intersection of Environmental, Energy and Agricultural Policy", *Applied Economic Perspectives and Policy*, 32(1), 4-32.

This paper assesses the efficacy of alternative biofuel policies in achieving energy, environmental and *agricultural* policy goals using economic cost-benefit analysis. Government mandates are superior to consumption subsidies, especially with suboptimal fuel taxes and the higher costs involved with raising tax revenues. But subsidies with mandates cause adverse

interaction effects; oil consumption is subsidized instead. This unique result also applies to renewable electricity that faces similar policy combinations. Ethanol policy can have a significant impact on corn prices; if not, inefficiency costs rise sharply. Ethanol policy can increase the inefficiency of farm subsidies and vice-versa. Policies that discriminate against trade, such as production subsidies and tariffs, can more than offset any benefits of a mandate. Sustainability standards are ineffective and illegal according to the WTO, and so should be re-designed.

Goswami, K. and H.K. Choudhury (2014), "To Cultivate or Not? Examining Factors that Influence Jatropha Agriculture in North East India", Working Paper 82-14, South Asian Network for Development and Environmental Economics, Kathmandu.

This study examines factors that determine the adoption and continued production of *Jatropha* in plantations in *North* East India. The study is based on a sample of 144 current-farmers, 137 previousfarmers, and 145 non-growers of *Jatropha* in the states of Assam and Arunachal Pradesh. The findings suggest that farmer characteristics such as their willingness to take risks, whether they have land that is not in use in agriculture, and knowledge of the product play an important role. Institutional factors such as availability of credit, and structural issues related to product and labor markets and travel time and distance are important considerations in whether *Jatropha* is adopted and plantations are continued. The study shows that, although there are serious bottlenecks to increasing *Jatropha* production, these problems can be remedied with some important institutional interventions. The study recommends extension of government credit facilities to farmers since the opportunity costs of labor and land, the initial low return, and the approximately 7-year payback period from *Jatropha* cultivation reduce farmer interest in continuing with *Jatropha* cultivation.

Goswami, K., J. Saikia, and H.K. Choudhury (2011), "Economic Benefits and Costs of Jatropha Plantation in North-East India", *Agricultural Economics Research Review*, 24, 99-108.

This paper assessed the profitability of jatropha plantation in four states of North-East India, viz. Arunachal Pradesh, Assam, Nagaland and Tripura, through cost-benefit analysis. The study has shown positive returns from the investment on jatropha plantation, making it an economically viable venture for the growers of the region. The investment on such plantation has shown a payback period of five years under the scenario of higher seed yield and accordingly requires adequate state funding support for operation and maintenance of such plantations at least during the initial years.

Gunatilake, H. (2011), "Financial and Economic Assessment of Biodiesel Production and Use in India", South Asia Working Paper Series, Number 8, Asian Development Bank, Manila.

This paper points out that financial analysis results may not provide a sound basis for public policy, particularly when there are distortions in the market. Biodiesel also has the potential to generate significant rural employment and to reduce greenhouse gas emissions. If biodiesel production to meet the 20% blending target is limited to wasteland, food production in India will not be affected. This paper explains the reasons why the biodiesel sector in India has failed to take off and argues that public sector interventions are needed to correct the market, nonmarket, and institutional failures that are preventing the biodiesel markets from developing.

Gunatilake, H. and P. Abeygunawardena (2014), "Energy Security, Food Security and Economics of Sugarcane Bioethanol in India", *Journal of Sustainable Development*, 7(1), 33-45.

This paper examines the economic feasibility of sugarcane bioethanol in India while considering the food security as a competing policy priority. The analyses show that 20% bioethanol standard cannot be achieved without affecting the food production in India. Moreover, cost of sugarcane bioethanol exceeds the social benefits, hence use of sugarcane bioethanol cannot be justified on economic grounds.

Hassan, M.H. and Md. Abul Kalam (2013), "An Overview of Biofuel as a Renewable Energy Source: Development and Challenges", *Procedia Engineering*, 56, 39-53.

Discussing all the advantages and disadvantages of biodiesel, this paper comprehends that, a dedicated biodiesel engine is the ultimate solution for commercializing biodiesel.

Haughton, A.J., A.J. Bond, A.A. Lovett, T. Dockerty, G. Sunnenberg, S.J. Clark, D.A. Bohan, R.B. Sage, M.D. Mallott, V.E. Mallott, M.D. Cunningham, A.B. Riche, I.F. Shield, J.W. Finch, M. M. Turner, and A. Karp (2009), "A Novel, Integrated Approach to Assessing Social, Economic and Environmental Implications of Changing Rural Land-use: A Case Study of Perennial Biomass Crops", *Journal of Applied Ecology*, 46, 315-322.

Using biomass crops planting as an example, this paper illustrates the potential of a Sustainability Appraisal Framework, subject to identification and agreement of appropriate indicators, in securing a holistic understanding of the wide-ranging implications of large-scale, long-term changes to rural land-use in the wider context of sustainable land-use planning *per se*.

Havlik, P., U.A. Schneider, E. Schmid, H. Bottcher, S. Fritz, R. Skalsky, K. Aoki, S. De Cara, G. Kindermann, F. Kraxner, S. Leduc, I. McCallum, A. Mosnier, T. Sauer, and M. Obersteiner (2011), "Global Land-use Implications of First and Second Generation Biofuel Targets", *Energy Policy*, 39, 5690-5702.

This paper uses GLOBIOM – an economic partial equilibrium model of the global forest, agriculture, and biomass sectors with a bottom-up representation of agricultural and forestry management practices. The results indicate that second generation biofuel production fed by wood from sustainably managed existing forests would lead to a negative iLUC factor, meaning that overall emissions are 27% lower compared to the ''No biofuel'' scenario by 2030. The iLUC factor of first generation biofuels global expansion is generally positive, requiring some 25 years to be paid

back by the GHG savings from the substitution of biofuels for conventional fuels. Second generation biofuels perform better also with respect to the other investigated criteria; on the condition that they are not sourced from dedicated plantations directly competing for agricultural land. If so, then efficient first generation systems are preferable. Since no clear technology champion for all situations exists, we would recommend targeting policy instruments directly at the positive and negative effects of biofuel production rather than at the production itself.

Hill, J., E. Nelson, D. Tilman, S. Polasky, and D. Tiffany (2006), "Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels", *Proceedings of National Academy of Sciences*, 103(30), 11206-11210.

Arguing that to be a viable alternative, a biofuel should provide a net energy gain, have environmental benefits, be economically competitive, and be producible in large quantities without reducing food supplies, this paper uses these criteria to evaluate, through life-cycle accounting, ethanol from corn grain and biodiesel from soybeans.

HLPE (2013), *Biofuels and Food Security*, a report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

This report – prepared at the behest of UN Committee on World Food Security by HLPE attempts to conduct a science-based comparative literature analysis taking into consideration the work produced by the FAO and Global Bioenergy partnership of the positive and negative effects of biofuels on food security.

Horst, D. van der and S. Vermeylen (2011), "Spatial Scale and Social Impacts of Biofule Production", *Biomass and Bioenergy*, 35, 2435-2443.

This paper explores the questions when and why negative social impacts are likely to occur and under what circumstances more positive impacts might be expected. These impacts are discussed for three geographically defined

biofuel supply chains; north-north, south-north and south-south. These three systems differ in the spatial scale of production and consumption and with that comes a different distribution of environmental, social and economic impacts. In the case of domestic production and consumption in developed countries, the social impacts are relatively minor and can be mitigated by social policies. Large scale, export-oriented production systems in developing countries could theoretically yield positive social impacts, but this would require on the one hand the tailored design of 'pro-poor' social innovations and interventions on the ground and on the other hand a certification of the supply chain feeding into consumer demand for 'ethical' fuel.

Kant, P., S. Wu, S. Chaliha, R. Jasrotia (2011), "Going Beyond Jatropha: Can an Expanded Land and Feedstock Base Help India Meet its Ambitious Biodiesel Target?", IGREC Working Paper IGREC-22: 2011, Institute of Green Economy, New Delhi

This paper argues that even after resource base enlargement, the annual biodiesel yield in 2020 is estimated at only 8.83 million tons enabling about 8% blending by that year. Since China is also intending to develop an ambitious biodiesel blending plan a limited comparison with China has been drawn. Huge demands for biodiesel in these countries would necessitate large scale imports unless there is a major technological breakthrough in lignocellulosic liquid biofuels. Experiences of past indicates that import of biodiesel in such large quantities could create severe adverse ecological and socio-economic consequences for the producing country, particularly if it happens to be a developing country with inadequate governance. For ecologically sustainable imports of such large quantities of biodiesel India and China would need to coordinate with concerned international bodies like FAO to develop appropriate import strategies well in advance.

Kumar, B., R.B. Hiremath, P. Balachandra, and N.H. Ravindranath (2009), "Bioenergy and Food Security: Indian Context", *Energy for Sustainable Development*, 13, 265-270.

This paper reports a case study of a typical district from India namely Tumkur and argues that optimal production of bioenergy can be achieved by using the wasteland present in the area. This way, food security for future generations can be maintained along with optimal growth of bioenergy.

Kumar, S., A. Chaube, and S.K. Jain (2012), "Critical Review of Jatropha Biodiesel Promotion Policies in India", *Energy Policy*, 41, 775-781.

Arguing that some serious bottlenecks are delaying the adoption of jatropha, this paper identifies important policy bottlenecks like availability of land, non-remunerative pricing policy and state fear relating to loss of revenue in the case of zero duty regimes. The paper attempts to explore and critically analyze present policies and possible options taking into account the recent Indian experiences for successful adoption of jatropha biodiesel.

Mohr, A. and S. Raman (2013), "Lessons from First Generation Biofuels and Implications for the Sustainability Appraisal of Second Generation Biofuels", *Energy Policy*, 63, 114-122.

This paper presents an overview of key first generation biofuel sustainability challenges, assess their relevance for second generation biofuels, and highlight the challenges for policy in managing the transition. It also addresses limitations of existing sustainability assessments by exploring where challenges might emerge across the whole system of bioenergy and the wider context of the social system in which bioenergy research and policy are done.

Naik, S.N., V. V. Goud, P.K. Rout, and A.K. Dalai (2010), "Production of First and Second Generation Biofuels: A Comprehensive Review", *Renewable and Sustainable Energy Reviews*, 14, 578-597.

This review focus on cost effective technologies and the processes to convert biomass into useful liquid biofuels and bioproducts, with particular focus on some biorefinery concepts based on different feedstocks aiming at the integral utilization of these feedstocks for the production of value added chemicals.

Naylor, R. (2012), *Biofuels, Rural Development, and the Changing Nature of Agricultural Demand*, Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century, Centre on Food Security and the Environment, Stanford University.

This paper reviews the main policy initiatives behind the 21st century biofuels boom - with specific attention to renewable fuel mandates - and describes how these policies influence food price levels and stability in international and national markets. It also explores the implications of an expanding biofuels industry for development policy and food security in countries with persistently high rates of hunger, including virtually all sub-Saharan African countries and India. The paper ends by suggesting three themes surrounding the debate over crop-based biofuels: 1) the dominant role of uncertainty in energy and agricultural markets, especially in light of new energy investments, financial instability, and climate change; 2) the importance of government policies and well developed supply chains as pre-requisites for profitable biofuel industries; and 3) the need to weigh opportunity costs to biofuels development in terms of fiscal expenditures, land and water resources, and political capital. These issues are particularly important for food insecure countries as they chart their development strategies for the future.

Naylor, R.L., A. Liska, M.B. Burke, W.P. Falcon, and J.C. Gaskell (2007), "The Ripple Effect: Biofuels, Food Security, and the Environment", Agronomy & Horticulture – Faculty Publications, Paper 386, University of Nebraska.

The potential impact of a large global expansion of biofuels production capacity on net food producers and consumers in low-income countries presents challenges for food policy planners and raises the question of whether sustainable development targets at a more general level can be reached.

Nazlioglu, S., C. Erdem, and U. Soytas (2013), "Volatility Spillover Between Oil and Agricultural Commodity Markets", *Energy Economics*, 36, 658-665.

This study examines volatility transmission between oil and selected agricultural commodity prices (wheat, corn, soybeans, and sugar). The paper shows that the dynamics of volatility transmission changes significantly following the food price crisis. After the crisis, risk transmission emerges as another dimension of the dynamic interrelationships between energy and agricultural markets.

Purohit, P. and G. Fischer (2014), "Second Generation Biofuel Potential in India: Sustainability and Cost Considerations", Report of the UNEP Riso Centre on Energy, Climate and Sustainable Development, Technical University of Denmark.

The paper argues that in light of food-vs-fuel debate the focus has shifted to the so-called second generation biofuels. Depending on feedstock choice and cultivation technique, second-generation biofuel production has the potential to provide benefits such as higher net greenhouse gas reduction and reducing competition with food consumption by consuming waste residues and making use of abandoned land. This study assesses the biomass resource availability in India from sustainably derived agricultural residues that can potentially be used for biofuel production.

Raju, B., P. P. Rao, K. Basu, Ch. R. Reddy, A. A. Kumar, P. S. Rao, B.V.S. Reddy (2013), "Assessing Viability of Bio-ethanol Production from Sweet Sorghum in India", *Energy Policy*, http://dx.doi.org/10.1016/j.enpol.2013.01.012

Arguing that the ethanol produced from molasses will not be able to meet the blending targets in India due to cyclical nature of sugar cane production resulting in shortage of molasses and its competing uses, this paper focusses on sweet sorghum for ethanol production. The paper assesses the viability of ethanol production from sweet sorghum and concludes that it will be difficult for the industry to take off under the current scenario of ethanol price,

feedstock price and ethanol recovery rate. It further argues for enabling environment and policy support for bio-ethanol production from sweet sorghum.

Raju, S.S., P. Shinoj, and P.K. Joshi (2009), "Sustainable Development of Biofuels: Prospects and Challenges", *Economic and Political Weekly*, Vol. XLIV (52), 65-72.

Keeping in view of the growing concerns about sustainability of biofuel expansion, this paper presents a brief overview of the current state of affairs of biofuels at the global level, with a special emphasis on the ongoing efforts of biofuel expansion in India. It throws light on the various policies at the national and regional levels and also on the implications of biofuels for changes in land utilisation, food security, social welfare and the environment.

Raju, S.S., S. Parappurathu, R. Chand, P.K. Joshi, P. Kumar, and S. Msangi (2012), "Biofuels in India: Potential, Policy and Emerging Paradigms", Policy Paper 27, National Centre for Agricultural Economics and Policy Research, New Delhi.

This paper addresses the rapidly evolving energy sector of India and the growth of first-generation biofuels as an alternative to fossil-based transportation fuels. It puts the development of this sector within the context of the complex policy environment in India and illustrates the key issues that confront the future development of this sector. The paper assesses the broad ramifications of the rapid and large–scale development of biofuels in India with the objective of identifying production potential and constraints to biofuels development.

Ravindranath, N.H., C.S. Lakshmi, R. Manuvie, and P. Balachandra (2011), "Biofuel Production and Implications for Land Use, Food Production and Environment in India", *Energy Policy*, 39, 5737-5745.

This paper presents an assessment of the implications of projected large-scale biofuel production on land available for food production, water, biodiversity, rural development and GHG emissions. The assessment focuses on first

generation biofuel crops and discusses technological and policy options required for promoting sustainable biofuel production.

Ray, S., A. Goldar, and S. Miglani (2012), "The Ethanol Blending Policy in India", *Economic and Political Weekly*, XLVII(1), 23-25.

This analysis of the Government of India's National Policy on Biofuels argues that while the policy of ethanol blending in petrol is in the right direction, it is fraught with several problems which are rendering the approach ineffective. The most critical ones are the lack of sugar cane for producing ethanol and the policy on pricing of it.

Sengupta, M. and A. Poddar (2013), "National Policy on Biofuel Under the Scanner", *International Journal of Emerging and Advanced Engineering*, 3(3): 521-526.

This paper takes into account the current unfulfilled targets and unevenness in the mandate and goals among state policies in India. Considering other country examples, the paper argues that there is a need for legislation and a strict mandate to be formulated.

Serra, T. (2011), "Volatility Spillovers Between Food and Energy Markets: A Semiparametric Approach", *Energy Economics*, 33, 1155-1164.

This paper focuses on price links between crude oil, ethanol and sugar prices in Brazil. The paper shows strong volatility links between the prices studied. The paper further argues that parametric approximations of the conditional covariance matrix may lead to misleading results that can be improved upon by using nonparametric techniques.

Serra, T. and D. Zilberman (2013), "Biofuel-related Price Transmission Literature: A Review", *Energy Economics*, 37, 141-151.

This article provides an extensive review of the rapidly growing biofuel-related time-series literature is carried out. The paper discusses the data used, the modelling techniques and the main findings of this literature. The review concludes that energy prices drive long-run agricultural price levels and that instability in energy markets is transferred to food markets.

Singhal, R. and R. Sengupta (2012), "Energy Security and Biodiesel: Implications for Land Use and Food Security", *Economic and Political Weekly*, XLVII(40), 66-73.

Arguing that widespread cultivation of biofuels could threaten the security of food and other agrarian supplies; this paper focuses on biodiesel production from jatropha oilseeds, assessing the profitability and competitiveness of energy cultivation and the chances of it replacing food or cash crop cultivation.

Thran, D., T. Seidenberger, J. Zeddies, and R. Offermann (2010), "Global Biomass Potentials – Resources, Drivers and Scenario Results", *Energy for Sustainable Development*, 14, 200-205.

This paper reviews the current state of biomass potential studies, discusses the essential driving factors for energy crop potentials and shows the results of a scenario analysis for worldwide energy crop potentials till 2050.

Tirado, M.C., M.J. Cohen, N. Aberman, J. Meerman, and B. Thompson (2010), "Addressing the Challenges of Climate Change and Biofuel Production for Food and Nutrition Security", *Food Research International*, 43, 1729-1744.

This paper reviews and analyses the current and projected effects of climate change and bioenergy on nutrition and proposes policy recommendations to address these challenges. The paper concludes with a series of policy proposals and recommendations to adapt to and mitigate the impacts of climate and global environmental change placing human rights in the centre of decision making. These proposals include a number of options for improving sustainability and food and nutrition security while addressing the links between climate change and bioenergy demand.

Upham, P., V. Kuttapan, and J. Tomei (2012), "Sustainable Livelihoods and Cultivation of Jatropha Curcas for Biodiesel in India: Reflections on Alternative Agronomic Models", Working Paper 150, Tyndall Centre for

Climate Change Research, University of Oxford and Newcastle University.

This paper discusses the sustainable livelihoods aspects of alternative Jatropha cultivation systems identified during fieldwork in three Indian states in 2009, based on site visits and senior manager interviews in three Indian states. The main cultivation systems found were: (a) cultivation by private fuel companies on leased ('captive') land; (b) cultivation by organised communities and by self-help groups on communal land; and (c) contract farming in which private companies in the fuel supply business contract farmers to cultivate Jatropha on the farmers' own land. The paper discusses these alternatives in relation to sustainable livelihoods concepts, contrast managers' views with other, much more critical research findings and highlight issues for further work.

Wise, T.A. (2012), "The Cost to Developing Countries of U.S. Corn Ethanol Expansion", Global Development and Environment Institute Working Paper 12-02, Tufts University, Medford.

Focusing on US Corn Ethanol expansion, this paper estimates the six-year costs to net corn importing countries at $11.6 billion, with developing countries absorbing more than half of those costs. Examining the negative impacts on the poor in net corn exporting countries, the paper argues in favour of reforms to U.S. biofuels policies.

Wright, B. (2014), "Global Biofuels: Key to the Puzzle of Grain Market Behavior", *Journal of Economic Perspectives*, 28(1): 73-98

This paper argues that to solve the puzzle of recent grain market behaviour it is necessary to incorporate into the market model, in addition to substitution between grains as sources of calories, and substitution between successive harvests via storage, a third key substitution, that of biofuels for petroleum-based fuels.

Zhang, Z., L. Lohr, C. Escalante, and M. Wetzstein (2010), "Food Versus Fuel: What do Prices Tell Us?", *Energy Policy*, 38, 445-451.

Using time-series prices on fuels and agricultural commodities, this paper investigates the long-run co-integration of these prices simultaneously with their multivariate short-run interactions. The paper shows the effect of agricultural commodity prices as market signals which restore commodity markets to their equilibria after a demand or supply event (shock).

Zilberman, D., G. Hochman, D. Rajagopal, S. Sexton, and G. Timilsina (2013), "The Impact of Biofuels on Commodity Food Prices: Assessment of Findings", *American Journal of Agricultural Economics*, 95(2), 275-281.

This paper summarizes the main findings of alternative lines of research on the relationship between the food and fuel markets and identifies gaps and quandaries that warrant further research. The paper distinguishes between two bodies of literature: one on the relationship between food and fuel prices and another on the impact of the introduction of biofuel on commodity food prices. While biofuel prices do not seem to affect food-commodity prices, the paper explains why the introduction of biofuel does. Further, the paper argues that biofuels have not been the most dominant contributor to the recent food-price inflation and different biofuels have different impacts.

Ziolkowska, J.R. (2011), "Fuzzy Multi-Criteria Framework for Supporting Biofuels Policy Making", *World Academy of Science, Engineering and Technology*, 59, 341-345.

This paper develops fuzzy algorithm and fuzzy multi-criteria decision framework and uses for a practical question of optimizing biofuels policy making. The methodological framework shows how to incorporate fuzzy set theory in a decision process of finding a sustainable biofuels policy among several policy options. Fuzzy set theory is used here as a tool to deal with uncertainties of decision environment, vagueness and ambiguities of policy objectives, subjectivities of human assessments and imprecise and incomplete information about the evaluated policy instruments.

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