Assessing Socioeconomic Impacts of Forest Biomass Based Biofuel Development on Rural Communities in the Southern United States

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ABSTRACT

The thirteen southern states spanning from Texas to Virginia with around 5 million private landowners, 28 percent of total forestlands and 62 percent of the country's total growing stock removals in 2006 are expected to play a dominant role in woody biofuels market development. Woody biofuels markets can contribute to rural development benefiting local communities by generating additional revenues to nonindustrial private forest landowners and other economic agents, stimulate employment and diversify rural economies. However, delineation of economic impacts on rural communities in the region has not been systematically analyzed.

In the project, we analyze the impact of woody biofuel development on rural communities in the Southern US. Specifically, we will: 1) assess key stakeholders' participation along the supply chains of loblolly pine (*Pinus taeda* L.) and slash pine (*Pinus elliottii* L.) based woody biofuel markets; 2) analyze potential direct economic and employment impacts on forestland owners and rural communities; and 3) estimate region-wide socioeconomic and distributional impacts of woody biofuel development. We will develop woody biofuel expansion scenarios based on market emergence in future and socio-economic acceptability considerations. Direct, indirect, and induced impacts on stakeholders will be estimated through Input Output Analysis and Social Accounting Matrix approach. Region-wide socio-economic and distributional impacts will be assessed using a Computable General Equilibrium model to identify winners and losers. We will discuss farm and regional impacts of woody biofuel expansion on non-metro (rural) counties in US South, including impacts on persistent poverty and minority dominated counties.

Here we describe the current state of forest based bioenergy and summarizes some of the major challenges and prospect relating to its technology and markets; relevant federal, state and local levels policies; and benefits and concerns relating to its sustainability. It also presents roles of loggers and transporters both in the value chain and their relevance in the economic viability of woody biofuels. After presenting this context, we outline specific objectives that the project

aims to address along with description of the methods that will be used to arrive at the said objectives. In doing so, we describe the geographic focus of the study and the role of private forest landowners in terms of their national relevance and as potential suppliers of biomass given their stake in the nation's forest resources. We also outline the preliminary results from the stakeholder meetings conducted in the three study states indicates that forestland owners were mostly aware of bioenergy production but were unsure about expressing their own price. The landowners who expressed their price preference tend to expect higher offers compared to pulpwood price to account for inconvenience and assumed risks. The information so generated is being used to develop a survey instrument that will be administered to randomly selected landowners in the three study states using Tailored Design Method. Our study will further understanding of the short and long-term impacts of woody biofuel expansion in US South and the ensuing socioeconomic impacts on rural landowners, minorities, and other rural groups.

INTRODUCTION

Studies have indicated that advanced biofuel from woody biomass has potential economic, social, and environmental benefits (Joshi and Arano 2009; Beach et al. 2005). These benefits include reduction of pest and fire outbreaks in over-stocked forests, biodiversity conservation, habitat protection, supplementing forestland owners' income, job creation, generation of local tax income, diversification of local economies, and reduction of poverty in rural communities. Policymakers at federal, state, and local administration level have developed several supporting policies that aim to capitalize on the potential benefits of woody bioenergy. These support systems take several forms including grants, loans, and tax credits (Zubrin 2008). Notable among these is the Energy Independence and Security Act that encourages the production of advanced biofuels from cellulosic sources like forest biomass by setting the target that by year 2022 it would form no less than 16 billion of the 36 billion gallons of the annual biofuel production (Congressional Research Service [CRS] 2012a).

The woody biofuel industry is still in a nascent stage where there are only a few demonstrations and pilot projects (Dwivedi et al. 2010). Furthermore, how willing forest landowners are towards supplying forest biomass for the emerging bioenergy industry, how much biomass will be supplied under different economic considerations, the market viability of the advanced biofuel therefrom, the short and long term socioeconomic and distributive impact of the sector, are not fully known. Additionally, the conversion technology, market, relevant public policy, and sustainability concerns represent part of the broader and interrelated context in the development of woody bioenergy sector.

Given the significant stake of private forestland owners in the management of the forest resource in the south, understanding their heterogeneity, what motivates their practices of biomass harvest, and which types of forestland owners are to supply biomass for bioenergy, are relevant considerations for woody bioenergy (Becker et al. 2011). This information will help improve our understanding of forestland owners' priorities, reservations, perceived opportunities and the challenges they face (Butler and Leatherberry 2004). It also has implications for designing informed extension work and policies and adapting existing ones to increase their effectiveness. Such information also helps us in getting a more realistic measure of potential biomass supply under different market conditions. This is of interest for stakeholders and supply chain actors in setting practical targets for bioenergy production, in decision-making regarding choice of technology, facility scale, location, other logistics, and in researching the competitive interaction with the traditional wood-based industry.

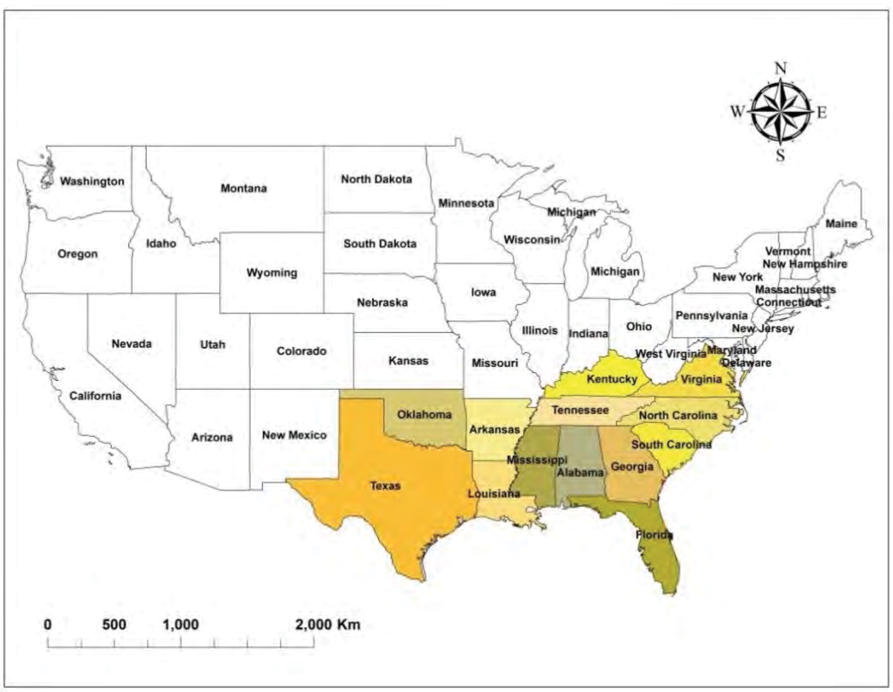

Fig. 1. Southern US States

The rest of the chapter is organized as follows. First, we discuss the geographic focus of the study and study objectives. We then turn to discussing the study methods in the second section. In the third section, we discuss literature review undertaken in terms of technology and market viability, sustainability, policies, and logging and transportation activities undertaken as part of the project. The fourth section briefly summarizes the research activities undertaken under the project and briefly provides our perspective for future research.

GEOGRAPHIC FOCUS AND STUDY OBJECTIVES

The US south, aided by a temperate and subtropical climatic patterns of temperature and rainfall, houses a third of the nation's forestland, and is a key player in the nation's timber market with the potential to produce up to half of the nation's advanced biofuel target (USDA 2010; Smith 2009; Prestemon 2002). The region has also seen increased investments in silvicultural treatment and genetic augmentation of forest growth rate over the past few decades (Munsell and Germain 2007). The loblolly pine (*Pinus taeda*) and slash pine (*Pinus elliottii*) are dominant in the region, where they account for more than 75% of the current forest plantation and a projected 34% increase in planted pine forest by 2060 (McKeand et al. 2003; USDOE 2011).

Within the south, the states of Alabama, Virginia, and Texas are home to a large pine forest stock (United States Geological Survey [USGS] 2013). Alabama has the highest loblolly and slash pine forest cover that has grown at an average rate of 3.3% over the last two decades and the state has now instituted cellulosic biomass pelletizing and co-firing plants (Alabama Forestry Commission 2011; Butler and Leatherberry 2004; Kebede et al. 2013). The Texas Department of Agriculture (2011) estimates that up to one million dry ton of logging residual wood is available for energy production, most of which is pine. These states also represent diverse geographic and natural conditions. The share of private forestland owners' in the total forest base in each respective state, their average acreage, socioeconomic makeup, and their likely supply response to market conditions such as emergent cellulosic biofuels sector, cannot be assumed to be similar (Sample 2009; Alavalapati et al. 2009). Furthermore, they exhibit differences in bioenergy penetration in the energy sector with regard to the number of processing plants that are present in each state (Ethanol Producers Association 2013). These features create the condition for evaluation of woody biofuels' key stakeholders' response to the sector, under different background scenarios.

Private landowners are an important stakeholder in forest resources management in the south, accounting for 60% of the forestland. This share has increased by 11% between the years 1993 to 2003, a trend that is projected to continue (Butler and Leatherberry 2004). The forest landowners have different socioeconomic and demographic attributes, environmental attitude, forest management objectives, and timber versus non-timber orientation, aesthetic values and environmental stewardship, market and extension experience, ethnicity, age, occupation, reliance on the forest to generate income, recreational value, and attitudes towards contribution to overall health of the environment. Further, these attributes are not all the same across different states and they are dynamic with respect to time (Markowski-Lindsay et al. 2012). Becker (2011) indicated that these different attributes affect forestland owners' forest management decisions, including whether or not to supply biomass for bioenergy.

Given its early stage of development, limited information is available on how much employment, income, and other economic impacts this sector will have. Further, the market viability of the product, market outcome of interaction with traditional wood industry, distribution of benefits, and losses among different stakeholders, are not fully documented. However, these need to be studied to evaluate the sector's overall sustainability, as well as the short and long-term socioeconomic and distributive impacts.

This study will field-test aspects of the sustainability of woody biofuels from loblolly pine (pinus taeda) and slash pine (pinus elliottii) in three southern states by ways of: (i) assessing forestland owners' biomass harvest intentions and participation in bioenergy markets; (ii) estimating biomass supply; (iii) assessing the financial competitiveness of slash and loblolly based biofuels, (iv) delineating the short term and long-term socioeconomic and distributive impacts of the woody biofuels; (v) assess region-wide economic and employment impacts of different woody biofuel development pathways including consideration for interaction with the traditional wood industry. Approach and methodology

We identified those that have stake or interest in bioenergy issues including key supply chain actors such as: forestland owners, loggers, transporters, processors, and distributors. We conducted literature review to understand if and how well these stakeholders are willing to participate in woody biomass supply market. This review also helped identify their priorities, expectations from the sector, the strength, opportunities, threats, challenges they perceive about the sector, and their interaction with others in the supply chain. Information was generated through direct interactions through landowner stakeholder meetings as well.

Quantitative and qualitative primary data will be collected through the use of survey instrument based on randomly selected private forestland owners from each state. The Tailored Design Method (Dillman 2007) will be adopted in administering the survey to increase response rate. Given the binomial attribute of the dependent variable in terms of participating or not in bioenergy markets, planting non-forested fields and adopting or not intensive management as a response to bioenergy market, increasing logging activities or not, investing in specialized transportation and processing equipment or not, among others, a logit model will be used. This will identify the factors that statistically explain stakeholders' responses using their respective socioeconomic, demographic and other relevant attributes. Further, a collective, pairwise, and two-way analysis of variance will be used to assess presence of a statistical difference and interaction in response to the survey questions among the three states, gender, ethnicity, age, and other categorical attributes within each stakeholder category. We will also use a principal component analysis to find a more condensed way of structuring the number of variables by identifying the most significant ones to develop a robust predictive model.

We include different bid prices in the survey. These bids were determined based on stakeholder meetings, expert feedback and tested through growth and yield models coupled with Timber Mart South price data. Response regarding how much will be supplied and how that response changes with bid offer will be assessed. These bids will also test what type of supply response behavior forestland owners will exhibit in terms of either adopting an intensive silvicultural practice or foresting previously non-forested fields. The least amount of bid offer they anticipate before considering to engage in any of these supply matters will be ascertained. These estimates will be aggregated to state and regional terms. Further, the responsiveness of supply to bid offer changes will be estimated in elasticity terms.

The input-output/social accounting matrix (IO/SAM) will be used to assess regional information on employment, industry output, personal income, commodity level supply and demand, state and federal government taxes and spending, capital investment, business inventories, value-added and domestic and foreign trade. I-O/SAM approach will be used to delineate the direct, indirect, and induced impacts. Further, this will be used in assessing the impact of woody bioenergy on persistent poverty and minority-dominated counties, the tradeoffs between the traditional forest product industry, agriculture and other sectors. We will also perform scenario analyses by altering the associated price, inventory, and removal responses. The I-O/SAM will generate a snapshot of the southern states' economy that will serve as the starting point for computable general equilibrium (CGE). This will be used to estimate the scale effects of woody biofuels and co-product markets on food, feed, and fiber systems. This will also be used to identify winners and losers and to estimate region-wide socioeconomic and distributional impacts.

We will estimate direct, indirect, and tradeoff impacts of woody biofuel expansion in southern states and delineate their impacts on rural communities predominantly residing in non-metro counties. We will follow the Office of Management and Budget (OMB) definition and discuss farm and regional impacts of woody biofuel expansion on non-metro (rural) counties in the study region. The tradeoffs between the traditional forest product industry, agriculture and other sectors of the southern economy will be evaluated.

FOREST BASED BIOENERGY STATUS

We reviewed the status of technology and markets, sustainability, policies, and logging and transportation, focusing more on the ways in which forest bioenergy issues have been approached by researchers, and the ensuing results. Although this section outlines the existing conditions in terms of most of the literature in context of forest based bioenergy, we focus less on the methodological aspects and rely more on outcomes.

Technology and Markets

The conversion cost contribution is a significant part of woody bioenergy's overall cost and plays an important role in its market competitiveness vis-a-vis starch-based biofuels and gasoline (Alavalapati et al. 2009). The market viability of woody bioenergy is important in achieving the biofuels and bio-power production targets, and reaping the associated socioeconomic and ecological benefits. Wood pellet industry has already achieved commercial success as demonstrated by its high demand in European markets owing to its high energy-to-volume ratio, ability to adapt production to demand and supply of biomass, low capital requirement, smaller handling and transportation costs (Dwivedi et al. 2010). Co-firing biomass with coal is another alternative as it does not require new facility. However, it faces technical problems such as ash deposition and corrosion. On the more expensive bioenergy options are woody biofuels, which are costly largely due to high harvesting, transportation, and storage costs (Frederick et al. 2008). Additionally, retrofitting delivery, storage and engines for higher blend levels could also have implications for its competitiveness (Becker et al. 2011). While the current state of development and type of technology in use affects bioenergy's market viability, how fast it becomes financially viable will contribute to the changes made in the conversion technology.

Because woody bioenergy is a nascent industry with limited data points from demonstration projects that have not gone commercial yet, the magnitude and timing of the change in demand and how that will reflect on its price, are not easy to forecast. However, the general direction is such that the outcomes of a rapid increase in demand of biomass for bioenergy could mean that urban wood waste, saw dust, shavings, chips, might not be sufficient in meeting woody biomass need for bioenergy and that merchantable timber and small diameter wood may be needed. This will raise biomass price paid by the forest product industry and increase the incomes of forestland owners who sell biomass, and sawmills that supply sawdust and chips. The rising competition might lead to reduced consumption of timber and even more of pulpwood by the forest industry as it is diverted to bioenergy projects (Alavalapati and Lal 2009).

The dynamics between rising demand and supply response can affect inventory and removal. The increased woody biomass for energy demand will be modulated by factors including increased rate of pine plantation, productivity enhancing measures, and rising proportion of fast growing biomass in the biomass stock (Munsell and Germain 2007). The type and rate of supply response might include increased participation of private forestland owners in the biomass supply market from an existing forest stand, adoption of intensive forest management strategies on currently forested land, conversion of currently non-forested land from being idle or in use for other purposes to pine, and short rotation energy crop plantations. However, the price effect of higher biomass demand might vary by the type of biomass, the region in consideration, and speed and magnitude of supply response to price incentives. Accordingly, softwood species that are more common in the south and have higher propensity to respond faster to the high demand than hardwood, will experience less pronounced price hikes (Alavalapati and Lal 2009). The role of government support in terms of research and development assistance, grants, tax breaks on capital costs will be paramount. Such resources can be used to optimize mechanisms to reduce biomass cost by improving yield and reducing transportation cost through densification of biomass to favorably change the weight to volume ratio, improve rate of technology development and conversion efficiency, and reduce market risk by crediting capital investments, among others (CRS 2012b).

Policies

Public policy has a role in incentivizing sustainable practices and penalizing unsustainable practices. Such policies relevant to bioenergy are in place and take the forms of tax credits for blending and production, import tariffs, rebates, depreciation allowance, grants, loans and loan guarantees, research and development, grants for small enterprises, training, and outreach (CRS, 2012b). The implementation for these policies can be either voluntary or mandated such as those with specific blending targets. The financial incentives help meet costs and enhance competitiveness while practices such as the mandatory blend requirement create the market for the bioenergy produce. These policies are administered by several agencies at the federal, state, and local levels including the department of agriculture (USDA), environmental protection agency (EPA), energy, internal revenue service, and customs and border protection (CRS, 2012a,b).

The renewable portfolio standards (RPS) devises market based approaches towards providing incentives and it also reduces costs associated with continuous government monitoring and enforcement. These policies provide incentives for renewable energy including solar, wind and hydroelectricity. How much bioenergy produced is, thus, influenced by how much of the state's energy is produced from other renewable energy sources (Dwivedi et al. 2010). At the state level, the timeframe and bioenergy's share of the renewable electricity production from private, municipal and cooperative utilities vary from a range of 4–30%. They also vary in terms of the approach of implementation by way of either voluntary or mandatory options. These variations result from differences in state-specific resource base, energy price, rural development agenda, and plan of action for climate change adaptation and mitigation, amongst others (Sample et al.2010). Desirable attributes of bioenergy policies include a shift from generic renewable energy incentives to specific woody bioenergy incentives that account for peculiarities of the sector and, in the process, help its effectiveness (Shivan 2010). This could also be helped if there is a sense of coordination in policy efforts to build synergy. Further, these policies should last sufficient time to build confidence in the market (Joshi and Arano 2009). Additionally, these policies should target the whole range of the bioenergy production cycle to avoid bottlenecks. Finally, the policies should allow for flexible compliance given limitations in low cost-high efficiency technology, feedstock supply issues and capital cost considerations (CRS, 2012a,b).

Sustainability

Projected production targets of biofuels and bio-power under the RPS place significant demand on forest biomass. Meeting this high demand could be at the cost of other ecosystem services of a forest, including conserving biodiversity, maintaining water quality and quantity, preserving wildlife habitat, and outdoor recreation. As such, it highlights issues relating to how much biomass that can be sustainably harvested and if the framework for implementing sustainability criteria currently exist. Failure to have such safeguards in place could have considerable negative consequences. Excessive harvesting of logging residue, tops, limbs, low value products, and deadwood for bioenergy may also affect the ecosystem health by impacting wildlife habitat, release of sequestered carbon, disrupting nutrient and water cycles, reducing soil organic content, and increasing erosion and deposition rates after precipitation events (Bucholz and Canham 2011). Furthermore, growing, transporting, and processing the feedstock involves fossil fuel consumption. Extensive application of fertilizers and pesticides and their potential runoff with impacts on drinking water and other uses, could be significant. Local, regional, and international direct, indirect, and induced land use change implications could also be substantial.

The multidimensional drivers and the potential impacts need to be understood and quantified to reduce unintended negative consequences while enhancing the positive ones. The magnitude and reversibility of the harmful impact may not be easily predictable. This may justify a prompt and precautionary management framework. The ability of existing best management practices that vary by state, and that were not originally designed for forest biomass-based bioenergy to handle the stated significant rise in demand for biomass, need to be studied. Left unchecked, the ensuing burden of ecosystem damage could be substantial (Evans and Perschel 2009). Sustainability practices can be promoted by applying specialized bioenergy guidelines, safeguards, enforcement, and be regularly updated. Lal et al. (2011) note that ecological sustainability indicators should include silviculture operation and management, land use change, greenhouse gas reduction, biodiversity conservation, soil quality, erosion, and water quality and supply. Such measures will ensure that benefits of woody bioenergy outweigh potential unintended costs.

Logging and Transportation

In addition to benefitting forestland owners, woody bioenergy development represents potential benefits to other parts of a biomass supply chain, which includes the logging industry. Loggers contract biomass from forestland owners, harvest, and transport it to processing facilities. The logging industry has recently experienced an aging workforce with low expectations for economic gains and a hesitation to recommend this line of business to others. Challenges in securing finance for machines; a volatile market that offers low prices despite high operation and fuel costs; and mill related issues of quotas, handling capacity, closure, and foreign competitions that have contributed to excess logging capacity are some of the primary concerns for this industry (Collins et al. 2008). Excess logging capacity leads to underemployment that result in loss of economic opportunity and limits return on equipment and labor investment (Bolding et al. 2010). As such, the emergence of woody bioenergy is expected to help address some of the industry's problems as treetops, branches, limbs from timber harvest, and pulpwood can be harvested by loggers to service bioenergy sector's demand (Greene et al. 2004).

Logging and transportation involve locating the biomass, cutting, pilling, bundling, forwarding, grinding, and hauling the biomass to the market. Each process presents opportunities and challenges for loggers harvesting small diameter trees and brushes for wood-energy use compared to their usual practice of commercial roundwood harvest in terms of the type, productivity, and specialty of equipment loggers' use. These challenges include ease of grabbing, lining up, and feeding chippers; sufficiency of their experience in harvesting small diameter tree and brush; terrain suitability; effect of small size on visibility; maneuverability of equipment without scarring standing trees; need for multiple entry and exit; and need for same time felling and bundling (Dirkswager et al. 2011). While woody bioenergy represents a potential opportunity for loggers, the following are not fully known: (i) how harvesting logistics considerations figure in terms of operation cost and overall economic feasibility for a given logger; (ii) the size, timing, and distribution of anticipated regional socioeconomic impacts; (iii) the increasing demand for biomass and its implications for stumpage price and change in the pattern of biomass procurement (as in fee and lease land, forestland owner assistance program, and open market purchase); (iv) loggers' perceptions of the prospect of the sector(what they identify as opportunity and challenge); (v) the ecological implications of production from different harvest systems (tree length, cut-to-length, and whole tree), type of harvest (pine clear-cut and thinning and hardwood clear-cut and thinning); and (vi) equipment (felling, skidding, delimbing, bucking, loading, trucking, chipping) (Leon and Benjamin 2012; Bolding et al. 2010). These issues are important because logging and transporting biomass make for a significant share of the feedstock cost for woody bioenergy and, thus, its overall economic competitiveness. In turn, Stidham and Simon-Brown (2011) note that how economically loggers can harvest, collect, and transport the small diameter biomass plays a role on the magnitude of impact of the emerging woody bioenergy sector on the logging industry.

PROJECT ACTIVITIES AND WAY AHEAD

Currently, the final preparations for administering the survey in three study states are in progress. Thus far, the survey has undergone several rounds of peer reviews from academicians and extension agents. Pilot runs were conducted to determine how forestland owners are likely to respond to it and their suggestions on survey questions were incorporated. Stakeholder meetings with forestland owners, minority landowners, extension agents, and academicians who have used landowner surveys in past were held. The stakeholder meetings in study states were used to develop bid values for landowner survey. Growth and yield model results coupled with price data from Timber Mart South was used to improve per acre stumpage price estimations. The triangulation process for bid values also included per acre stumpage price data gathered through sealed bid opening and timber sale award. Landowner survey responses will be analyzed to assess the underlying factors that explain forestland owners' willingness to supply biomass for energy production. These meetings and survey runs were made after obtaining certification and approval from the Institutional Review Board (IRB) at partner universities to conduct human participants based research in compliance with relevant state and federal laws.

As part of the project, investigators have published a literature review manuscript on economics of woody bioenergy as a chapter (Lal and Alavalapati 2014) in an upcoming book on Handbook of Forest Resource Economics. This work presents a summary of previous studies that apply principles of economics to measure and assess implications of woody bioenergy on the local and regional economies. It summarizes some of the more commonly used tools, findings, and the challenges resulting from varied models and their underlying assumptions. It highlighted some of the areas that have received recent research attention and future research needs required to better inform future public policy.

We are also currently conducting economic analyses to assess if conversion facilities can produce cellulosic ethanol at competitive prices. Towards this end, we are assessing the streams of income for a conversion facility from ethanol sales at different prices, capital investment and operating cost analysis to estimate unit cost of producing a gallon of gasoline equivalent cellulosic ethanol. Our preliminary results indicate that cellulosic ethanol can be produced at a competitive price at lower discount rates and prices that are 25% higher than the unit cost of producing a gasoline equivalent gallon up to the conversion stage. Similarly, the preliminary sensitivity analysis indicates that unit cost of ethanol is significantly influenced by changes in capital return factor and feedstock prices given their proportionally bigger role in the total cost. Such sensitivity of profitability to capital returns factor and feedstock prices may indicate a need for tax credits on capital investments or other forms of assistance to manage risk for conversion facilities.

This study adds to previous works by comparing multiple states instead of focusing on just one or, at most, two states. This helps in assessing similarities, differences, and how these inform policy, marketing and extension practices. It also adds a layer to previous participation in biomass market studies by estimating overall biomass supply under different market conditions to better predict how the sector may unravel as it develops. This will be done by improving on biomass availability estimation approaches by adding the layers of stumpage price, harvest, and transportation cost, estimating how many and which forestland owners, or what socioeconomic features are predictive of a willingness to participate in biomass supply market. Further, we will use this information to assess the big picture impact of the sector by estimating its market viability, competitiveness, profitability, assessing how the direct, indirect, and induced effects will be distributed, including its role in helping the rural poor.

This information can be used to identify the obstacles that stakeholders face and identify potential solutions in advance. The process can also help to better inform stakeholders about woody bioenergy. It also helps identify the types of social, economic, and policy circumstances that would encourage greater and continued participation and improve market outcome; determine the type and extent of intervention stakeholders consider to be more effective; and identify ways to increase overall local economic impact. By focusing on the different actors along the supply chain, policy and extension work recommendations that are relevant to each actor will be made possible. This information will be crucial in fostering the development of the emerging woody biofuels sector.

ACKNOWLEDGMENT

Authors gratefully acknowledge support for this chapter from US Department of Agriculture National Institute of Food and Agriculture Grant 2012-67009-19742.

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