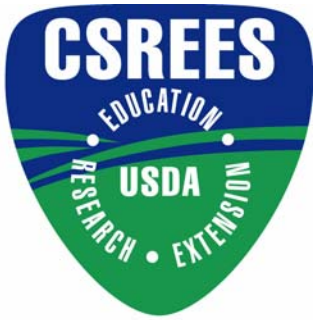
Discussion Paper

The Human and Social Dimensions of a Bioeconomy: Implications for Rural People and Places



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This discussion paper is a product of the Social Science Working Group (SSWG) of the Cooperative State Research, Education, and Extension Service (CSREES) of the United States Department of Agriculture (USDA). This paper's purpose is to introduce emerging issues in the human and social dimensions of bioenergy, biofuels, and biobased products, and to generate discussion and dialogue to further our goals for research, education, and extension for a sustainable biobased economy. The paper was written by Patricia Hipple, Jill Auburn, and Rob Hedberg, with guidance and assistance from members of the SSWG, as well as a number of CSREES colleagues from the agricultural, biophysical sciences, and engineering sciences.

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The Human and Social Dimensions of a Bioeconomy: Implications for Rural People and Places

Executive Summary

How will we ensure a secure energy future that rewards agricultural producers and rural communities for the value they create forging a new bioeconomy?

Production of bioenergy, biofuel, and bioindustrial products derived from agriculture is accelerating rapidly. On-farm energy conservation and efficiency is growing in importance as well. These trends create new opportunities, risks, and choices for U.S. farms; they fuel changes in the economy, social structures, and ecology of U.S. farms, rural communities, and landscapes, and foster dramatic changes in agricultural and woodland systems. This emerging bioeconomy affects decisions ranging from private land use choices to public infrastructure investment.

The important decisions associated with these rapid developments highlight the need for new bodies of knowledge and expertise in the social, human, engineering, and biophysical sciences. Education and outreach programs must then get this information and expertise to the people and communities facing these decisions.

Social scientists within CSREES have summarized herein many questions associated with these developments to identify knowledge gaps, researchable topics, and educational opportunities that will enable the agency to meet its objectives within the USDA Strategic Plan. We have identified research, education, and extension topics that can clarify the broad social, cultural, economic, and environmental implications of interactions among technologies, policies, behaviors, and management practices shaping the new bioeconomy.

This discussion paper will help characterize the myriad interactions that will ultimately shape the role of agricultural producers and rural communities in the expanding bioeconomy and its impact on them. It will to help us focus our efforts in research, education, and extension to help establish a sustainable bioeconomy with meaningful benefits for rural people, rural communities, and society in general.

Among the many questions that inspire these efforts are:

- *What are the best strategies to create, increase, and retain value from the bioeconomy for agricultural producers, private forest landowners, and rural communities? How can this be done sustainably?*
- *How does the accelerating bioeconomy affect markets for food, feed, and fiber? What are the implications for land values, U.S. energy security, and worldwide food security?*
- *How will the accelerating bioeconomy impact land use, crop rotations, marginal lands, forest management, conservation efforts, and the environment?*
- *Farms, landowners and managers, firms, and communities will face many decisions about participation in the bioeconomy. What factors should they consider and what information do they need?*

Broad systems changes require a systems approach to research, including interdisciplinary discussion among social and biophysical scientists, agricultural producers, community planners, industry experts, state and local governments, and others. These discussions should explore these and other questions, and identify the scientific opportunities, knowledge gaps, challenges, and priorities for future research, education, and extension activities to promote a sustainable biobased economy.

The Human and Social Dimensions of a Bioeconomy: Implications for Rural People and Places

Current Situation

U.S. agriculture is transforming as production of bioenergy, biofuel, and bioindustrial products augment the existing production of food, feed, and fiber. At the same time, advances in energy conservation and efficient technologies provide opportunities for on-farm energy savings. This transformation is affecting the economy, social structure, and ecology of U.S. farms, rural communities, and rural landscapes in both predictable and unpredictable ways.

The pace of this transformation is accelerating as several forces converge. The recent spike in energy prices coincides with technological advances and increased investment in alternatives. A growing number of federal and state actions, such as federal ethanol incentives, air quality regulations, and corporate average fuel economy standards, have added further impetus (Morris, 2006-2; USDA, 2006; Werner, 2006).

In 2005, President Bush announced a goal to reach 7.5 billion gallons of ethanol capacity by 2012. This Biofuels Initiative aims to replace more than 75 percent of U.S. oil imports by 2025. Policy discussions for the 2007 Farm Bill have encouraged inclusion of conservation, rural development, education, and energy provisions that would support a bioeconomy (USDA, 2006).

Title IX (Energy) of the 2002 Farm Bill (Public Law 107-171) included provisions for biorefinery grants, an Energy Audit and Renewable Energy Development Program, renewable energy systems and energy efficiency improvements, and biomass research and development to invigorate research and development of liquid fuels and bioindustrial products from biomass. Title VI (Rural Development) included Value-Added Agricultural Product Marketing Development. Title II (Conservation) created or expanded the Environmental Quality Incentives Program (EQIP), the Conservation Reserve Program (CRP), and the Conservation Security Program (CSP).

To date, bioenergy developments have focused primarily on liquid transportation fuel, especially corn ethanol, soy biodiesel, and cellulosic conversion. Focus is now shifting to creation of bioenergy, biofuel, and bioproducts from cellulosic biomass derived from various sources, including existing and new crops and their residues, trees and forest residues, and municipal or industrial wastes.

The transformation to a bioeconomy is dependent on agriculture, farmers, private forest owners, rural people and places, yet little scientific investment has focused on the human, social, and environmental dimensions of this transformation. Some observers have noted that current agricultural systems increasingly transfer economic and human assets out of rural economies (Cruse, 2006; Gronski, 2006), while others are concerned that the current state of the bioeconomy, particularly corn-based ethanol, is not socially, economically, or environmentally sustainable (Hunt, 2006; Koplow, 2006).

Many experts encourage a broad vision for agricultural and natural resource research "that is anticipatory; promotes long-term, systems-level research at multiple scales; better incorporates important interactions between the biophysical and social sciences; and provides for the proper evaluation of deployed solutions" (Robertson et al., 2004). A systems approach requires attention to geographic specificity, scale, and scope, as well as the ability to incorporate multiple levels of analysis, from the individual, to family and household, to farm and firm, to institutions, to rural communities, to ecosystem(s), and to the larger society, including the global community.

Potential Benefits

The bioeconomy is multifaceted, with many potential benefits. Elements include corn ethanol, soy biodiesel, electric co-generation with switchgrass, fuel and co-products from cellulosic biomass, energy from wind, solar, hydro or geothermal systems, energy efficient technologies, and industrial products from diverse farm and forest sources. Strong rural economies and improved environmental quality are among the anticipated benefits. A bioeconomy, along with energy conservation and efficiency, represents an opportunity to enhance farm viability and foster rural development.

As economic drivers of the farm sector, biobased energy, fuels, and value-added products may provide farmers with more crop rotation options, local premiums, higher crop prices, larger and more diverse domestic markets, new investment options, and savings in their own energy expenditures (Gronski, 2006; Kleinschmidt, 2005; Miranowski and Otto, 2005; Morris, 2006-1). Improvements in direct farm income and savings, coupled with high returns on farm and bioindustry investments, could multiply in local economies. Rural communities benefit as farmers increase purchases of local goods and services. Ancillary activities, such as processing, packaging, and transportation, can create more employment and revenue that is locally retained and reverberates through the local economy (English, 2006; Gronski, 2006; Kleinschmidt, 2005; Miranowski and Otto, 2005; Morris, 2006-1).

Nationally, a bioeconomy may reduce reliance on petroleum imports, hedge against higher petroleum costs and price volatility, reduce the trade deficit, improve the balance of World Trade Organization blue and green box payments through reduced commodity subsidies, and enhance wealth through carbon credits and green payments (Conway and Duncan, 2006; Morris, 2006-2; Werner, 2006). The decentralized nature of a farm-based bioeconomy lends itself to more distributed energy generation and reduces potential vulnerability due to congestion, disruption, or attack. U.S. petrochemical dependence can be reduced, strengthening our national security (Duffield, 2006; Duffield and Collins, 2006; USDA, 2006).

Rural biorefineries and biobased industries may create a cascade of economic benefits for farmers and rural communities (Borsboom, 2002; Domac, 2005). Wealth generated from a bioeconomy has great potential to circulate within a state (Morris, 2006-1; Gronski, 2006). Higher incomes, more local job opportunities, improved rural infrastructure and services, and increased tax revenues can yield an overall improvement in quality of life that may help stem rural out-migration (Gronski, 2006; Kleinschmidt and Muller, 2005; Kleinschmidt and Smith, 2006; Miranowski and Otto, 2005; Morris, 2006-1; Werner, 2006).

A strong bioeconomy may also provide significant environmental benefits. These include new non-polluting products, reduced wastes, reduced greenhouse gases, climate change mitigation, enhanced wildlife habitat, more biodiversity and better soil, water, and air quality (Conway and Erbach, 2004; Greene, 2004; Miranowski and Otto, 2005; Morris, 2006-1).

Potential Risks

Along with the potential benefits of a vibrant bioeconomy, come potential risks. For example, the recent rapid growth in demand for corn for ethanol could have adverse consequences for grain prices, food and feed availability, environmental effects, and impacts on rural communities. Competition in commodity markets, as well as changes in grain acreage, corn and soybean exports, and livestock feed, could have significant repercussions for farmers (Miranowski and Otto, 2005). Likewise, changes for handling and processing centers may be significant. For example, changes in the flow of commodities to local elevators or the Mississippi River may have large, long-term effects on infrastructure investment in storage facilities, rail capacity, roadways, and locks and dams.

Many uncertainties accompany future growth of biobased industries. Increased liquid fuel demands may require expansion of refining capacity such that new production plants replace smaller, less efficient units, and ethanol production shifts from community-based to industry-based (Morris, 2006-1). As a result, local communities may bear additional costs, while revenues accrue to distant owners. Likewise, larger-scale plants and vertical integration may disadvantage farmers and reduce potential income (Miranowski and Otto, 2005). As the industry matures, more stable prices may result, but fewer revenues will be retained locally. Biorefineries and bioindustries will demand new rural infrastructure and services, including roads, rail, sewage systems, and water. Without commensurate local revenues, rural communities could end up subsidizing the industry in return for local jobs that may not materialize if scale and efficiencies reduce the need for labor (Kleinschmidt and Muller, 2005).

High petroleum prices are expected to keep ethanol markets strong and encourage further growth of the industry. However, if oil prices plummet as they did in the 1970s, the economic viability of domestic alternatives would be threatened. Investments in a bioeconomy could be derailed and advances in biofuel and biomass technologies could stall. Benefits anticipated by producers and communities could evaporate, leaving the farm and rural sectors poorer and in debt.

Some analysts fear that the competition between food, feed, and fuel crops will reduce world food stocks and raise the cost of food, thereby threatening global food security and increasing hunger among the world's poorest and most vulnerable populations (Brown, 2006; Cook, n.d.).

The ethanol industry is expected to reduce exports and/or increase the acreage planted to corn and sorghum (Eidman, 2006; Gallagher, 2006; Miranowski and Otto, 2005). If high energy and biomass prices are sustained, land held in reserve for conservation may be converted to crops. More intensive commodity production may reduce anticipated environmental benefits by increasing use of fertilizers, pesticides, and water. Planting marginal lands for energy crops may intensify land competition for pasture and increase biomass costs on those lands, with farmers and rural communities bearing the brunt of the environmental and economic shocks (Gallagher,

2006; Kleinschmidt and Muller, 2005; Kleinschmidt and Smith, 2006). Environmental risks of an expanding bioeconomy also include threats to crop diversity, water quality and quantity, aquifer depletion, soil quality and soil depletion from over-cropping, and loss of conservation land (Greene, 2004; Hill et al., 2006).

Current Research, Education, and Extension Activities

CSREES supports collaborative research, education, and extension activities to address some of the many questions associated with the emerging bioeconomy. Most of this work has focused on biophysical research on feedstocks to produce bioenergy, biofuels, and bioproducts, along with cellulosic conversion technologies. More recent investments have focused on commercialization of biobased technologies. Our primary investments have been in the National Research Initiative (NRI), the Small Business Innovation Research (SBIR), the Sustainable Agriculture Research and Education (SARE), and Plant and Animal Systems (PAS) Programs. In addition, land-grant partners in many states have used Hatch Act Formula Funds, administered by CSREES, for such research. Very little research has been conducted on the human, social, and environmental dimensions of the bioeconomy, or complementary education and extension activities.

CSREES Activities

Conversion of biomass feedstocks to liquid fuels and bioindustrial products is the aim of the Biobased Products and Bioenergy Production Program in the NRI and the Agricultural Materials Program within PAS. One focus is to develop and improve cost-effective biological modification technologies for low-cost feedstocks that may generate high-value industrial biobased products. Another focus is to develop innovative non-food uses for biomass, especially underutilized co-products and agricultural residuals.

The SBIR Program promotes commercialization of new technologies and products. The Industrial Applications topic area focuses on developing new crops and technologies with potential to produce industrial products from agriculturally derived raw materials. The Rural and Community Development topic area recently shifted its attention to the economic feasibility of small-scale bioenergy production technologies that benefit rural communities. Energy-saving technologies, products, and services that mitigate adverse impacts of bioenergy production will also be explored.

The NRI Managed Ecosystems and Agricultural Prosperity for Small- and Mid-sized Farms Programs address on-farm management decisions, technologies, and farming practices relative to natural resource and environment issues, including land use, soil, water, and air quality, and economic success of small- and mid-size farms.

The SARE Program employs a regional structure, emphasizing producer participation in research and extension, with a focus on systems and sustainability. In so doing, it addresses agronomic, economic, environmental, and quality of life, issues.

Federal Collaborative Activities

CSREES participates on USDA's Biobased Products Bioenergy Coordination Council (BBCC). Established by the Secretary of Agriculture to coordinate activities and provide advice across the Department, the BBCC is the working arm of the Secretary's newly formed Energy Council, Which is expanding and accelerating the Department's activities in renewable energy. CSREES also participates in the Research, Education, and Economics Undersecretary's Agricultural Biobased Research, Education, and Extension Advisory Committee to identify critical issues and programming needs in the mission area.

CSREES collaborates with other federal agencies, interacting on a regular basis with the Department of Energy (DOE) Office of Science and the DOE Office of Biomass to develop programs and evaluate progress in key areas, including sequencing the soybean genome to optimize biodiesel production and joint solicitations for the Plant Feedstock Genomics Program and the Biomass Research and Development Initiative. CSREES is working with the Ethical, Legal, and Social Issues Program within DOE's Office of Biological and Environmental Research to convene an experts workshop that will explore research opportunities and identify priorities for integrated activities in the social and environmental dimensions of biofuels development. CSREES also maintains a database of individuals with expertise in the human, social, and environmental dimensions of the bioeconomy, especially the implications for rural people and places.

CSREES participates in the federal Woody Biomass Utilization Group, a joint venture among 11 federal departments and partners. This group supports utilization of woody biomass and residues from forest and woodland restoration efforts related to the President's Healthy Forests Initiative, National Fire Plan, Healthy Forest Restoration Act of 2003, and the Energy Policy Act of 2005. The group functions as a clearinghouse to help identify woody biomass utilization technologies, foster joint demonstrations and recommend pilot projects, identify research and development needs, and highlight successful community-based woody biomass projects.

Research, Education, and Extension Needs and Questions

To capitalize on the rewarding potentials and mitigate the adverse consequences for agricultural producers and rural communities, the human, social, and environmental dimensions of an emerging bioeconomy need to be addressed in integrated, systems-level scientific analyses. A comprehensive, systems approach will be required to examine the many scientific questions raised by an emerging bioeconomy, including agricultural and rural concerns, benefits, and risks. Walsh (2006) identified three broad research areas that warrant attention:

1. Evaluate the implications of the simultaneous development and commercialization of multiple, competing bioenergy, biofuels, and bioproduct uses. Such evaluation should take account of the different technologies and resource management practices, as well as agricultural, forestry, environmental, energy, fiscal, and rural development policies.
2. Evaluate the potential implications of resource competition, including changes in land and water use, forest management, crop management practices, crop prices and supplies, commodity payments, farm and non-farm income, potential and likely rural development

effects, and environmental impacts such as soil, air, and water quality, wildlife habitat, and emissions.

3. Evaluate these implications at multiple scales because crops, farming practices, forest management, suitable feedstocks, and rural communities vary significantly by geography and resource endowment. Analysis is needed ranging from individual farms through community, ecosystem, regional, national, and global community levels.

A systems approach would focus attention on the entrepreneurial and rural development potential of the bioeconomy, including such things as industry and ownership structures, financing, credit, and investment options; risk management tools for feedstock and biofuel producers; and local governance issues such as workforce development, infrastructure, and service needs, and the economic well-being of community participants. This approach would also focus on the impacts of crop production, forest management, and bioproduct processing and distribution on air, water, soil, biodiversity and carbon sequestration, leading to a fuller understanding of the environmental benefits and risks of an expanding bioeconomy.

The following sample questions on the human, social, and environmental dimensions of an emerging bioeconomy are drawn from the literature, research findings, experts' reports, academic discussions, visioning exercises, and popular press. These questions will inform discussions of scientific opportunities and investment priorities in research, education, and extension.

The Human Interface with Natural Resource and Environmental Issues

- What fuel sources most effectively supply economic, social, and environmental benefits?
- What new crops, cropping systems, forest management practices, machinery and techniques for harvesting, storing, and transporting biomass are required for its sustainable development? How will these affect biomass demand, production and supply, and refinery development and location? What are the economic implications of natural resource and environmental issues for rural economies, people, places, and landscapes?
- What are the natural resource requirements for different biorefining systems? For example, what growing and refining systems use water most efficiently? How will changes in water use and demand affect rural communities and rural water systems?
- How will biorefinery wastes and residues be managed? Will disposal affect property values, agricultural lands, or the local environment? Are appropriate protections in place?

Market and Equity Issues

- What factors influence industry and consumer acceptance of biobased products, processes, and technologies? What marketing methods best provide farmer and landowner income and other societal benefits?
- Will crop acreage increase or will there be a shift in crop use from food, feed, and fiber to fuel? What are the substitution issues? For example, how will distillers dried grains with solubles (DDGS) affect corn, soybean, and livestock markets?
- Are there dietary implications if grains and by-products are less available for animal production or if the price and availability of corn sweeteners changes significantly?
- Will new domestic markets for energy and industrial products influence agricultural and wood products trade issues? To what extent will domestic energy alternatives displace oil

imports and reduce trade deficits? How will price volatilities and input prices affect rural communities? What effect will new domestic markets for energy and industrial products have on rural economies?

Decision-making and Incentives

- What factors influence individual farmers' and forest landowners' decisions to grow energy and alternative crops, employ new technologies, or use their land for wind or solar energy production? What incentives are most effective and impediments most restrictive? How do profit, risk, reputation, resources, equipment configuration, financial status, support networks, learning curves, community and family attitudes influence adoption?
- What crop and product attributes, infrastructure and market characteristics, and financial and community support programs facilitate or impede adoption?
- What incentives influence feedstock production and biomass conversion, biorefining infrastructure and capital investments, and consumption of biobased fuels and renewable energy?
- How can commercial biomass feedstock enterprises acquire the economic skills and market information needed to evaluate, develop, and sustain biomass supplies?
- What mix of incentives, investment, and formal or informal education are needed to nurture a new generation of biomass farmers?
- What financing and decision-making tools most effectively overcome barriers to new investment and promote development and commercialization of new products?
- What specialized risk management tools are needed to protect agricultural producers and locally-owned biorefineries? What contract methods are most effective and accessible?
- What are the educational and training needs for the bioeconomy? How can rural schools and communities, land-grant institutions, and industry cooperatively meet these needs?

Rural and Community Development

- What are the best strategies to help agricultural producers and rural communities create, increase, and retain value from the bioeconomy? What leadership skills will help rural communities capitalize on available resources to participate in the bioeconomy?
- How can rural communities manage shifts that may include increased ownership concentration, fewer farms, and less local control of farming and biorefining systems?
- If more grain is retained locally for biorefining, what are the impacts for people and communities whose livelihoods are intertwined with the current grain shipping, handling, and storage infrastructure oriented to export markets?
- What opportunities does an evolving bioeconomy provide for rural revitalization, including replacement of aging physical infrastructure with redesigned new components that are flexible, secure, and internationally competitive? What assistance will rural communities need to capitalize on these opportunities?

Biorefining Systems and Structures

- Will the bioeconomy result in more crop production for specific differentiated end uses? Would such a shift affect the structure, ownership, and beneficiaries of the bioeconomy?
- What are the effects of scale in the development of biomass facilities? How will the scale of facilities affect job creation, transportation costs, and industry concentration? What are

the most effective ways to mitigate adverse consequences? What biorefining systems and structures optimize benefits for local communities through retention of local wealth?
- What biorefinery ownership structure generates the most value for rural economic development and creates the most wealth for rural economies, while providing optimum benefits for society at large? What policy options impact distribution of benefits?
- Will the increasing availability of DDGS affect the location and configuration of feeding operations in the cattle, hog, or poultry industries? What are the waste management and environmental implications of such shifts?
- Fuel production from animal waste will benefit large feeding operations more than small ones. What are the implications for small- and medium-size farms and animal welfare?

Research and Development

- What are the best practices for administering grants, loans, and loan guarantees to stimulate product development? What are the comparative rates-of-return on public investment in bioenergy, biofuels, energy efficiency, and energy conservation research?
- Can international partnerships in research and development (R&D) help retain local and rural benefits from the bioeconomy? What R&D funding mechanisms facilitate such ventures?

Regional and International Issues (Geography and Geopolitics)

- What feedstocks are appropriate in different regions of the country?
- What regional, spatial, and cultural differences will influence local adoption of various energy conservation, biomass production, and biorefinery activities?
- What can be learned from the successes and shortcomings of prior biomass production and conversion endeavors in the United States and other countries?

Conclusions

The human, social, and environmental dimensions of an emerging bioeconomy are many, and may interact with biophysical and engineering factors in complex ways. The diversity and complexity of the many questions identified above reinforce the need for an integrated, systems approach to research, education, and extension activities that addresses the bioeconomy. Essential to such an approach is consideration of 1) the varied levels of analyses necessary; 2) the objective of multi-faceted sustainability; 3) the complexity and interconnectivity of elements within systems; 4) the porosity of system boundaries; and 5) the combined land-grant missions of research, education, and extension.

CSREES and other federal agencies are engaged in interdisciplinary discussions with social scientists, agricultural producers, community planners, industry experts, state and local governments, and others expert in this emerging bioeconomy to identify scientific opportunities and priorities for needed investments in research, education, and extension. We are providing leadership and guidance to land-grant partners already engaged in these activities to assist them in their work with agricultural producers, consumers, and communities to forge sustainable biobased economies that accrue meaningful benefits to rural people, places, and landscapes, as well as the broader society.

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