Planting Food or Fuel:

Developing an Interdisciplinary Approach to Understanding the Role of Culture in Farmers' Decisions to Grow Second-Generation Biofuel Feedstock Crops

Stacey Swearingen White, J. Christopher Brown,

Jane Gibson, Eric Hanley, Dietrich Earnhart

Revised, January 2010

We acknowledge funding from the National Science Foundation (NSF) Experimental Program to Stimulate Competitive Research (EPSCoR, EPS-0903806) and the University of Kansas Transportation Research Institute (KU-TRI).

Planting Food or Fuel:

Developing an Interdisciplinary Approach to Understanding the Role of Culture in Farmers' Decisions to Grow Second-Generation Biofuel Feedstock Crops

Abstract: Recent interest in biofuels as an alternative energy source has spurred considerable change in agricultural practice worldwide. These changes will be more pronounced as second-generation biofuels, such as switch grass and algae, gain prominence. This paper examines the cultural factors associated with the decisions U.S. farmers face in targeting crops for fuel production instead of food. Through an interdisciplinary assessment of the dynamics of farmers' behavior, we develop a theoretical framework to analyze how farmers grapple with shifting expectations of their function.

1. Introduction

Interstate drivers in the heartland of the United States cannot help but notice signs along the highway reminding travelers of where our food comes from: "Beef, it's what's for dinner," "Pork, the other white meat," and "1 Kansas farmer feeds 128 people + you." New signs over the last several years, however, have gone beyond food to remind us of the source of some of the fuel facilitating our travel. These remind us of the importance of US farmers in providing corn-based ethanol over oil, especially oil from governments that are hostile to the US. Reportedly, one sign in South Dakota read, "BANKRUPT TERRORISTS! Foreign Oil Funds Terrorism. Use Ethanol, Biodiesel and Other USA Fuels."[1] These symbols along the bi-ways of the US agricultural landscape are one guide, albeit crude, to what the land means to those who farm it, and why it should matter to those who are passing through. Regardless of one's stance on climate, energy, and US national security, the signs remind observers that farmers will increasingly face the choice of whether to plant food for people and animals, or fuel for our transportation needs. This choice will become even more important as technology improves to produce fuel from cellulosic, second-generation sources. Eventually, US farmers may decide to plant crops exclusively destined to fuel our transportation needs with petroleum alternatives.

Understanding the dynamics of the choices farmers make in adapting their practices to biofuels opportunities is a complex undertaking that requires a multidisciplinary approach. This paper asks: "what frameworks and concepts are available to guide research on the cultural factors, broadly construed, that affect the decisions farmers make about planting second-generation biofuels crops? While challenging to develop, an integrative approach, reflecting

[1] From a story by Mikkel Pates of Grand Forks Herald, September 22, 2002 posted on http://www.e85fuel.com/news/fyi/101002fyi.htm (last viewed on October 30, 2009).

several disciplines and theories, provides a fuller appreciation for the cultural intricacies involved in the ongoing transition to alternative energies, particularly as that shift involves farmers.[i]

2. Political Ecology and Chains of Explanation

One way to proceed in our analysis is to consider a conceptual framework that purposively broadens the scope of our research. Such an approach would move beyond frameworks that pay exclusive attention to either micro-level factors of the farm/farmer or to macro-level factors of the national and international environments. One such framework is political ecology, an approach to research on human-environment interactions that has developed within a broad range of social science disciplines since the 1970s. The approach traces its roots to cultural ecology, a major focus of anthropological and geographical research that, among other foci, drew out the importance of cultural practices in allowing societies to survive by using appropriate technologies to adapt to their environments (Steward, 1972; Rappaport, 1967). Much of cultural ecology has centered on traditional societies in the developing world. Due to their relative isolation, these societies offered researchers the clearest and purest cases of environmental and cultural interaction. As traditional societies became more linked with the global political economy, it became more difficult to make these connections, given that traditional livelihoods and use of natural resources were being affected by factors operating in the wider regional, national, and global political economy. This development prompted the creation of political ecology.

The framework of political ecology places at the center of analysis the “land manager” whose decisions cause impacts on the landscape that are not seen as mere cultural adaption to local environmental circumstances. Rather, political ecology leads researchers to view land manager decisions as made within a variety of natural, social, and cultural contexts at different spatial scales: local, regional, national, and global (Wolf, 1972; Blaikie, 1985; Blaikie and Brookfield, 1987; Paulson and Gezon, 2005). This attention to varying scales of analysis in studies of decision-making has been referred to as "progressive contextualization" (Vayda, 1983). Blaikie and Brookfield (1987) described this approach as engaging in a "chain of explanation" of a land manager's decisions by considering a variety of factors.

Political ecology has largely been applied in studies of rural land use in developing countries, but more recently, researchers have been applying the conceptual framework to studies of urban areas in the developing and the developed world (Myers, 2005; Swyngedouw, 2004; Robbins, 2007; Brogden and Greenberg, 2005). Brogden and Greenberg (2005), for example, examine the conversion of Arizona ranchlands for urban development, a situation not dissimilar to our inquiry, in that agriculturalists must weigh many factors in deciding upon new land practices. Considering that some studies even use this framework to examine US homeowners' decisions regarding lawn care (Robbins, 2007), it follows that such a framework could be used in an interdisciplinary study of farmer decision-making in Kansas. After all, the Kansas "farmer" is a land manager, the person who combines his/her labor with capital equipment, technologies, and materials in order to work the land. Moreover, the decision to plant crops for fuel instead of food is probably like any other decision: it is formed through complex interactions involving natural, social, and cultural factors operating at a number of different spatial scales, from the level of the individual farmer to the levels of global dimensions – both physical and institutional.

The analytical methods of political ecology are extremely diverse. And political ecology lends itself to a number of disciplinary approaches. Some typical methods employed, however, bear mention here. One method is ethnography, the close study of a particular social group that begins in our project at the level of the individual farmer on her or his farm and often involves various forms of participatory research. In anthropology, respondents help guide the research and, in some recent studies, construct models that attempt to explain farm-level decisions. In geography, the creation of land maps is a way to engage the land manager in the research. This creation potentially offers quantitative spatial data that researchers can use to compare cognitive environments and decision outcomes within and across communities of land managers.

Archival research is also common in political ecology. Primary data gathered at the group level, such as cooperative offices, can reveal the history of proximate social relations that influence decisions. For example, studies may explore how information about new technologies is channeled through cooperatives. Researchers also may collect political and economic data from secondary sources in order to describe the broader local, state, national, and global contexts of land manager decisions.

The goal of much political ecological research is not to identify *the* factors that help to explain land managers' behavior. Rather, the goal is to increase awareness of the interdependent environmental, cognitive, social, economic, geographic, and political structures that affect those decisions. The effort often calls for greater attention to the views and needs of local land managers, often neglected in policy debates within, and in decisions made by, large institutions (e.g., US Department of Agriculture). This attention seems even more necessary recently since land managers often face decreased livelihood possibilities due to the political, economic, and cultural pressures of globalization.

The sections that follow expand on these ideas by developing an analytic framework that improves our understanding of the complex interactions of the factors influencing farmers' decisions to grow second-generation biofuel feedstock crops.

3. Developing an Integrated Conceptual Framework to Categorize Factors Influencing Farmers' Decisions

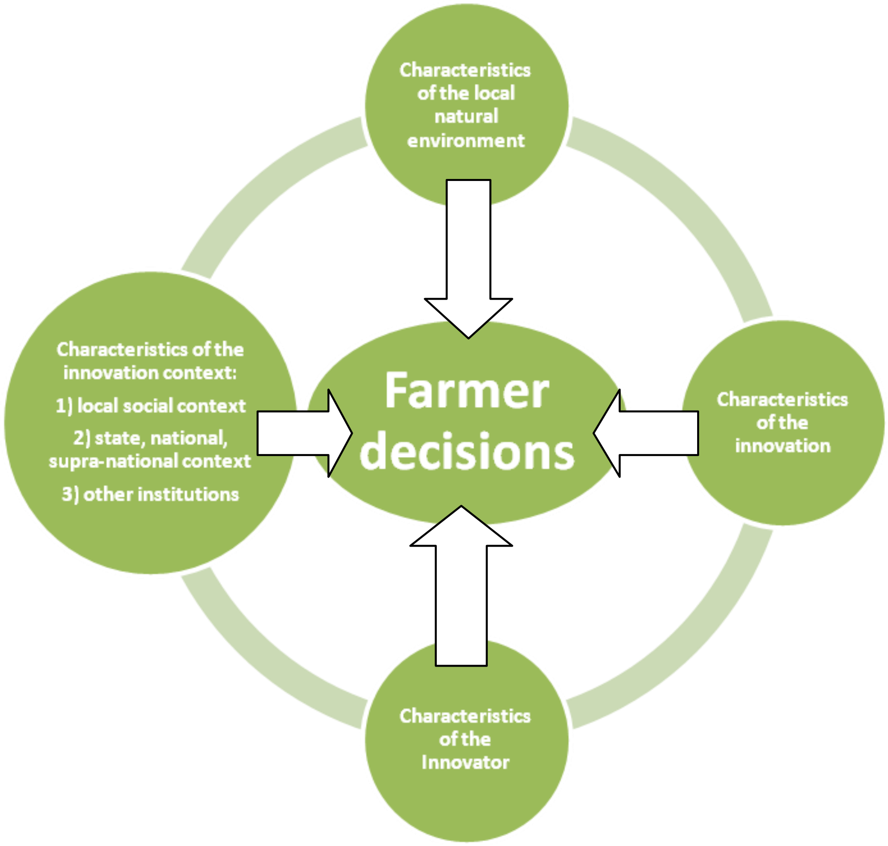
3.1. Organization

Since political ecology recognizes that many factors help to explain farmers' decisions, including decisions to adopt new practices, we do not attempt to document the vast array of explanatory variables identified by previous studies. Instead, we develop a framework that integrates multiple theories at different scales of analysis. In addition to the insights of political ecology, we recognize that innovation diffusion theory provides a useful lens for considering categories for organizing these explanatory variables. In that an innovation is "an idea, practice or object that is perceived as new by an individual or other unit of adoption," (Rogers, 2003, p. 12), farmers growing crops as feedstocks for second-generation biofuels are innovators. Unlike first-generation biofuels, where the crop (corn) remains the same and only the market differs, second-generation biofuels production may involve different choices of crops (e.g. switch grass) and land management practices (e.g. collection of crop residues). Instead of producing food, farmers who engage in production of second-generation biofuels are growing alternative energy sources.

Wejnert (2002) argues that variables to explain innovation decisions can be grouped into three categories: (1) characteristics of the innovator, (2) characteristics of the innovation, and (3) characteristics of the context in which the innovation occurs. We expand on these categories by applying the notion of *scale*, recognizing that characteristics of the local natural environment are also critical to farmer decisions, and that the innovation context can be examined along multiple dimensions, including levels of government involvement, and the influence of other institutions such as media organizations.

As noted earlier, analysis of farmers' decisions to innovate by growing crops as biofuel feedstocks is a complex undertaking, spanning explanatory factors beyond those we include. Nevertheless, our integrated conceptual framework provides a much more comprehensive and interdisciplinary structure to identify explanatory factors and more deeply and broadly understand the choices farmers make. Consistent with the framework described above, we explain the categories within a set of interrelated spheres of context. Specifically, we expand from the biological and physical environment to the individual farmer in local social context and then to institutional influences at state, national, international, and global scales. Figure 1 illustrates our conceptual framework.

Figure 1: Conceptual Framework for Understanding Farmer Decisions



3.2. Characteristics of the Local Natural Environment

At the most basic level, the condition of the local natural environment influences an individual farmer's innovation decision to adopt a new practice. Certainly, the characteristics of the land under cultivation appear to affect farmers' decisions (Fliegel, 1993; Negri and Brooks, 1990; Nieswiadomy, 1998; Saltiel at al., 1994). In particular, Negri and Brooks (1990) demonstrate that soil texture and slope affect farmers' innovation adoption decisions, while Nieswiadomy (1988) shows that overall land quality influences such decisions. For farmers debating a switch to second-generation biofuel crops, the specific characteristics of his or her land, as well as the quality and availability of water to support new crops, are most likely important analytic dimensions.

3.3. Characteristics of the Innovation

Beyond the natural environment's characteristics, the next most basic category of explanatory factors concerns the characteristics of the innovation itself. An empirical meta-analysis provided by Rogers (2003) identifies five aspects of an innovation that contribute to an individual farmer's decision to adopt a new practice. First, the *relative advantage* provided by the innovation affects the farmer's decision. In other words, is the new practice better than a current practice? If the new practice generates identifiably better benefits for the farmer, it is more likely that a farmer would adopt the new practice. Second, the *compatibility* of the new practice with the existing farmer's operations affects the farmer's decision. Put differently, does the innovation fit with the farmer's current practices? Farmers who perceive new practices as compatible with their current operations are more likely to adopt them. Third, the *complexity* of adoption influences the farmer's decision. In other words, is the innovation easy to implement? If not, adoption is less likely. Fourth, the "*trialability*" of the new practice should matter. Potential innovators ask: can the innovative practice be piloted or tested in a small scale? If so, an individual farmer can gather information about the new practice before committing to full adoption. In essence, trialability helps the individual farmer lower the risk of adoption. Moreover, it allows an individual farmer to "learn by doing" at least in a small way. (We return to this point below in sub-section 3.5.) In both cases, greater trialability should increase the likelihood of adoption. Fifth, the "*observability*" of the innovative practice affects the farmer's decision. In other words, can the practice be seen in place elsewhere? If it can, the farmer is able to learn by scrutinizing other farmers' experiences before committing to the new practice. Of course, the boundary of the farmer's social network influences *whose* other experiences the individual farmer scrutinizes. (We return to this point below in sub-section 3.5.) Regardless of the boundary, greater observability should increase the likelihood of adoption.

To these five innovation characteristics, we add a sixth: degree of risk. Farmers are keenly aware of the degree of risk associated with a new practice. As risk rises, any risk-averse farmer is less likely to adopt the innovative practice. This concern does not apply to risk-neutral decision-makers and is reversed in the case of risk-loving decision-makers. While many individual exceptions exist, the risk-adversity farmers perceive is reflected in the strong prevalence of crop insurance policies, forward and future contracts, and other risk-reducing devices.

Different studies find different levels of importance concerning the influence of these innovation characteristics. Ryan et al. (2003), for example, find that relative advantage, observability and compatability are all important for explaining farmers' decisions to adopt conservation practices in riparian areas. Thus, our future research should consider characteristics of second-generation biofuel crops as important factors for explaining farmers' decisions to grow these crops (i.e., innovate).

3.4. Characteristics of the Innovator

The first two categories of explanatory factors involve humans only indirectly, through their observations and perceptions of land and innovation characteristics. At the very core of our analysis, though, lies the human decision-maker: the individual farmer. The third category of explanatory factors concerns characteristics of the (potential) innovator. This category excludes all references to other humans or social institutions (i.e., collections of humans). Not surprisingly, characteristics of the innovator also help to explain innovation decisions.

A range of important variables, drawn from multiple theoretical perspectives, helps elucidate the characteristics of the innovator, in this case, the farmer. In anthropology, for example, participatory methods have shifted the focus of agricultural research from commodity-centered questions to farmer-centered approaches that recognize the importance of *local knowledge* and *expertise*. Cognitive scientists agree that local knowledge systems shape farmers' decisions, and failure to understand the roles these systems play in identifying, interpreting and responding to constraints on farmers' decisions can be the difference between effective and failed policies (Gladwin et al., 2002).

Maloney and Paolisso (2006), Paolisso and Maloney (2000a,b), Maloney (2009), and Raedeke and Rikoon (1997) demonstrate that American conventional farmers are indeed reliant on local knowledge systems. To understand the ways farmers use local knowledge, these studies use in-depth ethnographic interviews to elicit farmers' culture models. Such models "are presupposed, taken-for-granted models of the world that are widely shared (although not to the exclusion of other, alternative models) by the members of a society and that play an enormous role in their understanding of that world and their behavior in it" (Holland and Quinn, 1987, p. 4).

Culture models show what farmers believe about the physical, social, economic, and political world they inhabit. They take into account psychological and emotional states that, when coupled to motivation, produce action. They illuminate what farmers value, how they interpret challenges and opportunities, their understanding and valuation of historical, physical and social contexts, and they show what farmers strive to protect and achieve. In short, culture models seek to explain "why" farmers do what they do as a function of their cognitive processes that are themselves embedded in shared experiences and meanings. Culture models reveal implicit knowledge because explicit cultural knowledge is necessary but insufficient to understand the beliefs and values within which decision-making is embedded (D'Andrade 1995, 2005). Because individuals, whether farmers or members of other social groups, cannot usually articulate their culture models, the models are returned to respondents who can validate them or help refine them. Therefore, these models are described in the vernacular of those whose frameworks they represent.

Culture models such as those illuminated by Maloney (2009) on Chesapeake Bay farmers, and Paolisso (2002) on Chesapeake Bay watermen, are produced through analysis of in-depth ethnographic interviews that encourage individuals to share their thoughts about their farms and farming experiences. Farmers' shared culture models can provide useful insight into how they interpret and respond to the possibility of second generation biofuel crop cultivation.

Decisions to adopt new crops can be further understood with innovation diffusion theory. One diffusion study of farmer adoption of new seed types, for example (Rogers 2003), finds that previous experience in adopting a hybrid corn variety resulted in significantly higher rates of adoption for hybrid sorghum. Thus, familiarity with an innovation is a personal characteristic that may influence its adoption. It is reasonable to expect that a farmer would need to have both awareness of and information about an innovation (Laurian 2003) in order to pursue its adoption.

The degree of risk or uncertainty associated with an innovative practice also influences a farmer's decision. While this feature represents a characteristic of the innovation, the attitude towards risk – risk-neutral, risk-averse, and risk-loving – represents a characteristic of the innovator. When the adoption of an innovative practice involves highly uncertain benefits and costs, it may be very difficult, if not nearly impossible, for an individual farmer to assign meaningful probabilities to a wide variety of different outcomes. Many studies, especially neoclassical economic studies, ignore this difficulty by assuming that an individual farmer is fully capable of evaluating all of the uncertain outcomes and identifying the choice that maximizes his/her expected utility. In contrast, other studies, especially behavioral economic studies, assess “heuristics”, which represent cognitive devices that individual use to make decisions (“approximate rules of thumb”) in situations where meaningful probabilities are very difficult to assign (Kahneman et al., 1982; Thaler, 1983). When confronted with such a situation, an individual farmer has the tendency to rely on “traditions,” which are practices that worked in the past, or “stereotypes,” which represent categorizations on the basis of certain characteristics opposed to others. Reliance on such heuristic devices is expected to introduce bias into the decision-making process, resulting in an underestimation of risk in some instances and an overestimation in other instances.

3.5. Characteristics of the Local Social Context

An individual farmer, with his or her personal characteristics, does not live in a vacuum but within a local social context. Consequently, characteristics of the local social context in which the potential innovator resides also influence adoption of the new practice. Despite the varied emphases of previous research using the innovation theory component of our integrated conceptual framework, this research points consistently to the importance of social relationships and communication channels as key influences on a potential adopter’s decision as whether or not to innovate. Ryan and Gross (1943) claim that farmers’ social networks can be critical in facilitating the adoption of innovative agricultural practices. While not specific to farmers, Abrahamson and Rosehnkopf (1997) argue that understanding the structure of social networks in an innovation setting is essential to understanding the likelihood of adoption. Similarly, Rogers

(2003) claims that each potential adopter draws on his/her interpersonal networks to evaluate the decision to try something new.

A farmer's social network seems especially important when the "adoptable technology" is very new, implying that the returns on the use of the technology are highly uncertain. While farmers are certainly able to learn more about the true performance of the technology based on their experiences, farmers may learn even more based on the experiences of other farmers who have adopted the technology. Empirial evidence indicates that farmers learn how to cultivate a new crop based on the choices of other farmers cultivating the particular crop (Besley and Case, 1997; Foster and Rosenzweig, 1995; Conley and Udry, 2003; Munshi, 2004). In particular, an individual farmer's initial decision to adopt a new technology may be strongly affected by the decisions of other farmers to whom the individual farmer feels socially connected (Baardhan and Udry, 1999). In other words, while the observability of the new practice may be influential, the social connection to other farmers may play a key role as well.

To demonstrate how an individual farmer's adoption decision is influenced by what they learn about other farmers' experiences (hereafter "social learning"), some economic studies of agricultural decisions employ a target input model in which farmers use probability-based updating to learn about the expected performance of a risky new crop technology (Bandiera and Rasul, 2006; Foster and Rosenzweig, 1995; Bardhan and Udry, 1999). The farmer is able to learn about the risky technology by using the technology and assessing the realized performance. In the process, his/her understanding of the technology's performance becomes more precise. In essence, each farmer can "learn by doing," which increases output.

Of course, farmers can also learn about the risky technology from other farmers' experiences. By observing the experiences of other farmers, again an individual farmer improves the precision of his/her understanding of the technology's performance. As other farmers experiment more with the risky technology, the individual farmer "socially learns" and output increases. These relationships between learning and output affect each farmer's initial decision to adopt the new risky crop technology. In particular, the number of adopters in an individual farmer's social network is expected to affect positively the individual farmer's initial adoption decision since a greater number of adopters increases the informational transfer, which improves the farmer's understanding of the technology, improving expected performance.

Since an individual farmer benefits from social learning, one might expect that a farmer would learn from as many farmers as possible. However, a farmer's "social network" may or may not include certain agents. For example, a social network may consist solely of family members and friends. Then again, a social network may include geographically similar farmers, i.e., neighbors, or culturally similar farmers, e.g., farmers sharing the same religion or religious background. Identifying the "boundary" of a farmer's social network helps to locate the cultural constraints on technology adoption (Bandiera and Rasul, 2006). In particular, information on the experience from all other farmers should help to inform a particular farmer's adoption decision. However, for cultural reasons, an individual farmer may draw his/her "social network boundary" tightly, ignoring the experiences of farmers who seem "different."

In addition to the highly important social networks, other characteristics of the local social context affect farmers' adoption decisions. Broad cultural attitudes may prove important. Sommers and Napier (1993), for example, find that Amish cultural attitudes towards soil and land protection resulted in greater levels of adoption of sustainable agriculture practices in Amish communities relative to adoption in non-Amish communities. As another explanatory factor, Feder and Umali (1993) explore the influence of status characteristics on farmers' innovation decisions.

3.6. Characteristics of the State, National, and Supra-national Context

Beyond the local social context, individual decision-makers are embedded within a state politico-economic context, which in turn is embedded within a national politico-economic context, that is in turn embedded within a supra-national politico-economic context (e.g., World Trade Organization, European Union, North American Free Trade Agreement). The characteristics of these non-local contexts represent the next category of factors influencing individual farmers' innovation adoption decisions. Agricultural policies implemented by state governments, national governments, or supra-national entities represent the best examples, such as commodity price supports. (While agricultural policies clearly represent decisions made by policy-making bodies, e.g., United States Department of Agriculture, from the standpoint of an individual farmer, our conceptual framework appropriately regards these policy choices as "characteristics" since no individual farmer is able to manipulate these policy decisions. Of course, an individual farmer is able to relocate in order to enjoy the benefits from different agricultural policies. This additional dimension need not disrupt the application of our integrated conceptual framework.) Obviously, numerous studies, arguably too numerous to mention, examine the influence of agricultural policies. Since these factors generally do not involve cultural dimensions, we do not dwell on this category.

3.7. Characteristics of Other Institutions

In addition to characteristics of obvious governmental or political entities operating within a variety of contexts (e.g., state), the characteristics of other social institutions – including both formal and informal organizations – also help to explain an individual farmer's decision to adopt an innovative practice. Characteristics of the social institutions ("institutional context") prove important for explaining individual farmers' decisions because institutions' actions play a prominent role in developing and disseminating rules of understanding, including their influence on the processes of classification and representation, e.g., risk perceptions. (Similar to government bodies, we classify the actions of institutions as "characteristics" because they are beyond the control of the individual farmer.) In particular, social institutions manipulate rules for decision-making by supplying stereotypes that make some cases seem more representative than others, by framing choices in characteristic ways, and by suggesting reference points.

We highlight the feature of "framing", which refers to the way adoption of an innovative practice is presented to decision makers by social institutions, such as business groups and media organizations, and government organizations. Some studies, in particular, highlight the manner in which organizations purposefully manipulate perceptions of the risk associated with the adoption of innovative practices by means of rhetorical strategies that magnify certain features of a phenomenon (Taylor, 1984; Best, 1987). For example, a number of studies demonstrate that issues figuring more prominently in the media are more likely to be adopted as heuristic devices than those issues that receive less attention (e.g., Best, 1987). Other studies show that some organizations, such as corporations and governments, are more able to disseminate their interpretive frames than others (Molotch and Lester, 1975; Raymond, 1985). The tendency of individual decision-makers to rely on "frames" constructed by institutions most likely represents a systematic source of bias in decision-making processes.

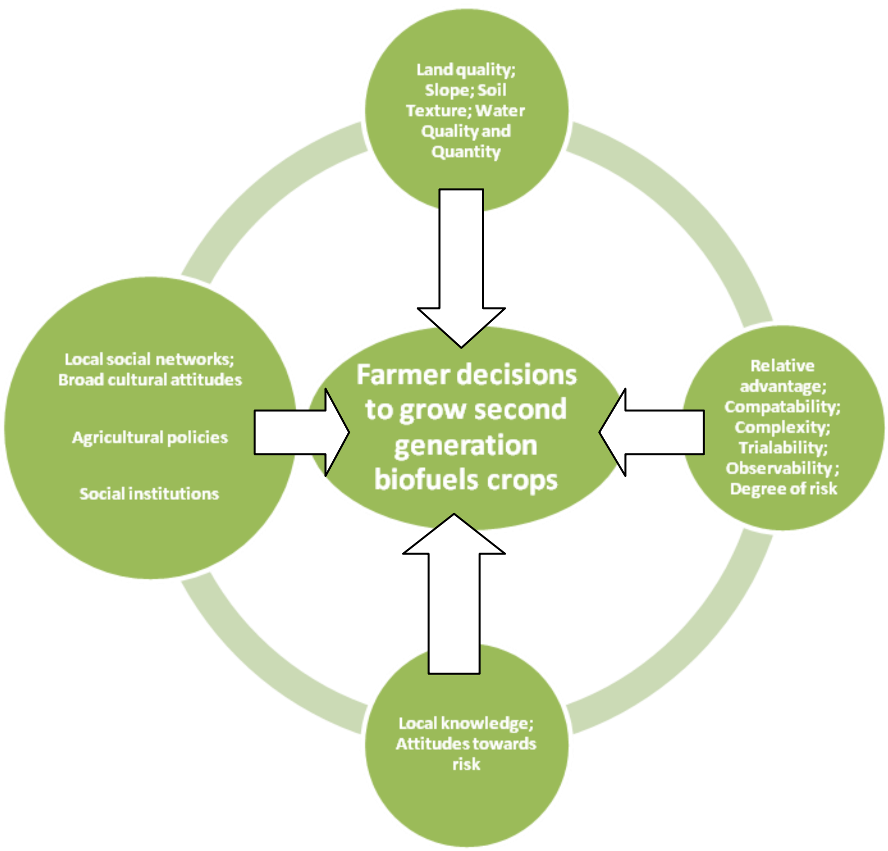
Lastly, social institutions influence the distribution of risk to which individual farmers are exposed by adopting innovative practices. Regulatory agencies, insurance companies, and banks (and other credit organizations) are important examples of influential institutions. The risk-management strategies adopted by these influential institutions represent one set of characteristics of the institutional context in which farmers operate. For example, the institutional distribution of risk clearly played an important role in facilitating farmers' decision to increase their production of corn. Over the past few years, the percentage of farmers who purchased crop insurance has risen dramatically, with total premiums more than doubling between 2002 and 2007 (Worth, 2008). This suggests that farmers would not have responded to price signals to the extent they did if those institutions which reduced the risks associated with devoting a larger amount of land to corn production were not present. Furthermore, this turn toward crop insurance among the first generation of fuel-crop producers suggests that similar institutional arrangements will need to be in place before farmers will display a willingness to take on the risks associated with the production of second-generation fuel crops.

4. Discussion and Conclusion

On its face, our attention to scale, based on a broadly interpreted political ecology, may appear to be too general to be useful. While researchers generally develop conceptual frameworks to narrow their focus, ours initially expands this focus. But perhaps it is the general property of scale in political ecology that makes it suitable as an approach to the *interdisciplinary* study of farmer decisions. Scale and political ecology are overarching frameworks designed to broaden the focus of any work involving people and the environment. Within them, any number of more focused frameworks can fit, in accordance with the expertise and interests of research team members.

We can already take the broad conceptual framework introduced in Figure 1 and render it more precise. Figure 2 shows the specific yet interdisciplinary factors previous research suggests may be the more important characteristics to help explain farmers' particular decisions to grow second generation biofuels crops. Attentiveness to variables ranging from land quality to local knowledge, and from agricultural policies to the observability of a new practice will allow us to make more informed decisions about data collection and analysis. We expect to discover a full array of influences on these farmers' decisions. As biofuels become an increasingly important element of U.S. alternative energy production, understanding these influences will be critical.

Figure 2. Understanding Farmer Decisions to Grow Second Generations Biofuels Crops



Attentiveness to scale throughout this collaborative project provides a means of integrating diverse disciplinary perspectives. Truer interdisciplinary understanding can be achieved when particular researchers, using their own particular frameworks, comprehend how their research fits into a greater whole.

References:

Abrahamson, E. and L. Rosehnkopf. 1997. Social network effects on the extent of innovation diffusion: A computer simulation. *Organizational Science.* 5, 3: 289-309.

Ahnström, J., Höckert, J., Bergea, H. L., Francis, C. A., Skelton, P., and L. Hallgren. 2009. Farmers and Nature Conservation: What is known about Attitudes, Context Factors and Actions Affecting Conservation? *Renewable Agriculture and Food Systems.* 24, 1: 38-47.

Bandiera, O. and I. Rasul. 2006. Social Networks and Technology Adoption in Northern Mozambique. *Economic Journal*. 116, October: 869-902.

Bardhan, P. and C. Udry. 1999. Development Microeconomics. Oxford: Oxford University Press.

Besley, T. and A. Case. 1997. Diffusion as a Learning Process: Evidence from HYV Cotton. Mimeo, Princeton University.

Best, J. 1987. Rhetoric in Claims Making: Constructing the Missing Children Problem. *Social Problems*. 34: 101-21.

Blaikie, P. 1985. The Political Economy of Soil Erosion in Developing Countries. New York: Longman Scientific and Technical.

Blaikie, P., and H. Brookfield. 1987. Land Degradation and Society. London and New York: Methuen and Co. Ltd.

Brogden, M.J. and J.B. Greenberg. 2005. The Fight for the West: A Political Ecology of Land-Use Conflicts in Arizona, in Paulson and Gezon (eds.) Political Ecology Across Spaces, Scales, and Social Groups. New Brunswick, NJ: Rutgers University Press. Pp. 41-60.

Conley, T. and C. Udry. 2003. Learning about a New Technology: Pineapple in Ghana. Mimeo, Yale University.

D’Andrade, R. 1995. The Development of Cognitive Anthropology. New York: Cambridge University Press.

D’Andrade, R. 2005. Some Methods for Studying Cultural Cognitive Structures. In Finding Culture in Talk: A Collection of Methods. Naomi Quinn, ed. New York: Palgrave Macmillan. pp. 83-104.

Darnhofer, I., Schneeberger, W., and B. Freyer. 2005. Converting or Not Converting to Organic Farming in Austria: Farmer Types and Their Rationale. *Agriculture and Human Values.* 22, 1: 39-52.

deJanvry, Alain. 1979. Nature of Rural Development Programs: Implications for Technology Design. In Economics and the Design of Small-Farmer Technology. A. Valdes, G. Scobie, and J. Dillon, Eds. Ames, IA: Iowa State University Press. pp. 179-193.

Fairweather, J. R. 1999. Understanding How Farmers Choose Between Organic and Conventional Production: Results from New Zealand and Policy Implications. *Agriculture and Human Values.* 16, 1: 51-63.

Feder, G. and Umali, DL. 1993. The adoption of agricultural innovations: a review. *Technology Forecasting and Social Change.* 43: 215-239.

Fliegel, FC. 1993. Diffusion research in rural sociology: The record for the future. Westport, CT: Greenwood Press.

Foster, A. and M. Rosenzweig. 1995. Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture. *Journal of Political Economy*. 103: 55-298.

Gladwin, C. H. 1975. A Model of the Supply of Smoked Fish from Cape Coast to Kumasi. In Formal Methods in Economic Anthropology. Stuart Plattner, Ed. Washington, DC: American Anthropological Association. pp. 77-127.

Gladwin, C.H. 1976. A View of the Plan Puebla: An Application of Hierarchical Decision Models. *American Journal of Agricultural Economics* 58: 881-887.

Gladwin, C. H. 1977. A Model of Farmers' Decisions to Adopt the Recommendations of the Plan Puebla. Ph.D. dissertation. Stanford University.

Gladwin, C. H. 1979. Cognitive Strategies and Adoption Decisions: A Case Study of Non-adoption of an Agronomic Recommendation. *Economic Development and Cultural Change* 28 1: 155-173.

Gladwin, C.H. 1989. Ethnographic Decision Tree Modeling. Newbury Park, CA: Sage Publications, Inc.

Gladwin, C. H., Peterson, J. S., and A. C. Mwale. 2002. The Quality of Science in Participatory Research: A Case Study from Eastern Zambia. *World Development.* 30, 4: 523-43.

Holland, D., and N. Quinn, eds. 1987. Cultural Models in Language and Thought. New York: Cambridge University Press.

Kahneman, D., Slovic, P., and A. Tversky, eds. 1982. Judgment under Uncertainty: Heuristics and Biases. Cambridge, UK: Cambridge University Press.

Laurian, L. 2003. A Prerequisite for Participation: Environmental Knowledge and What Residents Know about Local Toxic Sites. *Journal of Planning Education and Research*. 22: 257-269.

Li, T. M. 2000. Locating Indigenous Environmental Knowledge in Indonesia. In Indigenous Environmental Knowledge and Its Transformations: Critical Anthropological Perspectives. R. Ellen, P. Parkes, and A. Bicker, eds. Amsterdam, the Netherlands: Harwood Academic Publishers. pp. 121-149.

Maloney, R. S. 2009. Cultural Models, Farm Management, and Agricultural Nutrient Runoff: A Maryland Case Study of The Role of Culture in Nutrient-Management Policy. Ph.D. Dissertation. Department of Anthropology. University of Kansas.

Maloney, R. S. and M. Paolisso. 2006. The "Art of Farming": Exploring the Link between Farm Culture and Maryland's Nutrient Management Policies. *Culture & Agriculture*. 28, 2: 80-96.

Molotch, H., and Lester, M. 1975. Accidental News: The Great Oil Spill as Local Occurrence and National Event. *American Journal of Sociology*. 81: 235-60.

Moscardi, E. R. 1979. A Methodology to Study Attitudes toward Risk: The Puebla Project. In Economics and the Design of Small-Farmer Technology. A. Valdes, G. Scobie, and J. Dillon, Eds. Ames, IA: Iowa State University Press. pp. 30-41.

Moscardi, E., and A. deJanvry. 1977. Attitudes toward Risk among Peasants: An Econometric Approach. *American Journal of Agriculture Economics*. 59: 710-716.

Munshi, K. 2004. Social Learning in a Heterogeneous Population: Social Learning in the Indian Green Revolution. *Journal of Development Economics.* 73: 185-213.

Myers, G. A. 2005. Disposable cities: garbage, governance and sustainable development in urban Africa. Ashgate Publishing: Hampshire, England.

Negri, D.H. and D.H. Brooks. 1990. Determinants of irrigation technology choices. *Western Journal of Agricultural Economics*. 15: 213-23.

Niewswiadomy, M.L. 1988. Input substitution of irrigation agriculture in the high plains of Texas, 1970-1980. 13: 63-70.

Normile, D. 2000. Asia gets a taste of genetic good fights. *Science.* 289 :1279-1281.

Paolisso, M. and R. S. Maloney. 2000a. Farmer Morality and Maryland's Nutrient Management Regulations. *Culture & Agriculture*. 22, 3: 32-39.

Paolisso, M. and R. S. Maloney. 2000b. Recognizing Farmer Environmentalism: Nutrient runoff and Toxic Dinoflagellate Blooms in the Chesapeake Bay Region. *Human Organization*. 59: 209-221.

Paolisso, M. 2002. Blue Crabs and Controversy on the Chesapeake Bay: A cultural Model for Understanding Watermen's Reasoning about Blue Crab Management. *Human Organization*. 61: 226-239.

Paulson, S. and L. L. Gezon, eds.. 2005. Political Ecology Across Spaces, Scales, and Social Groups. New Brunswick, NJ: Rutgers University Press.

Pottier, J. 2003. Negotiating Local Knowledge: An Introduction. In Negotiating Local Knowledge: Power and Identity in Development. J. Pottier, A. Bicker, and P. Sillitoe, eds. Sterling, VA: Pluto Press. pp. 1-29.

Raedeke, A. H. and J. S. Rikoon. 1997. Temporal and Spatial Dimensions of Knowledge: Implications for Sustainable Agriculture. *Agriculture and Human Values*. 14: 145-158.

Rappaport, R. 1967. Ritual Regulation of Environmental Relations among a New Guinea People. *Ethnology*. 6: 17-30.

Raymond, C. A. 1985. Risk in the Press: Conflicting Journalistic Ideologies. In The Language of Risk. D. Nelkin ed. London: Sage.

Robbins, Paul. 2007. Lawn People: How grasses, weeds, and chemicals make us who we are. Philadelphia: Temple University Press.

Rogers, E. M. 2003. Diffusion of innovations, 5th ed. New York: The Free Press.

Ryan, B. and Gross, N. 1943. The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociology*. 8, 1: 15-24.

Ryan, R. L., Erickson, D. L., and R. De Young. 2003. Farmers' Motivations for Adopting Conservation Practices along Riparian Zones in a Mid-Western Agricultural Watershed. *Journal of Environmental Planning and Management.* 46, 1: 19-37.

Saltiel, J., Bauder, J.W., and S. Palakovich. 1994. Adoption of sustainable agricultural practices: diffusion, farm structure, and profitability. *Rural Sociology.* 59: 333-349.

Samboda, L. A. A. T. 2007. The Decision Making Processes of Semi-Commercial Farmers: A Case Study of Technology Adoption in Indonesia. Ph.D. Dissertation. Lincoln University, New Zealand.

Sommers, D.G. and T.L. Napier. 1993. Comparison of Amish and non-Amish farmers: a diffusion/farm-structure perspective. *Rural Sociology*. 58: 130-145.

Steward, J. H. 1972. Theory of Culture Change: The Methodology of Multilinear Evolution. Urbana, IL: University of Illinois Press.

Swyngedouw, E. 2004. Social power and the urbanization of water: flows of power. Oxford, England: Oxford University Press.

Taylor, S. 1984. Making Bureaucracies Think: The Environmental Impact Strategy of Administrative Reform. Stanford, CA: Stanford University Press.

Thaler, R. H. 1983. Illusions and Mirages in Public Policy. *Public Interest*. 73: 60-74.

Vayda, A. P. 1983. Progressive Contextualization: Methods for Research in Human Ecology. *Human Ecology*. 11, 3: 265-81.

Villa Issa, M. 1976. The Effect of the Labor Market in the Adoption of New Production Technology in a Rural Development Project: The Case of the Plan Puebla, Mexico. Ph.D. Dissertation. Purdue University.

Wejnert, B. 2002. Integrating Models of Diffusion of Innovations: A Conceptual Framework. *Annual Review of Sociology*. 28: 297-326.

Winkelmann, D. 1976. The Adoption of New Maize Technology in Plan Puebla, Mexico. Paper presented to an International Seminar on Accelerating National Agricultural and Rural Development. Arranged for AIDS by the University of Reading.

Wolf, E. 1972. Ownership and Political Ecology. *Anthropological Quarterly*. 45: 201-5.

Worth, T. 2008. Discussion: The 2007 Farm Bill and Crop Insurance: Implications for Crop Producers in the South. *Journal of Agricultural and Applied Economics*. 40, 2: 461-64.

---

[i] The authors of this study comprise a multidisciplinary team of social scientists recently formed to study the decisions farmers make about planting second-generation biofuels crops instead of food. As a collaborative effort, the authors face the challenge of integrating various disciplinary approaches, rather than simply placing them side by side.