Forecast Skill and Farmers’ Skills: Seasonal Climate Forecasts and Agricultural Risk Management in the Southeastern United States

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ABSTRACT

During the last 10 yr, research on seasonal climate forecasts as an agricultural risk management tool has pursued three directions: modeling potential impacts and responses, identifying opportunities and constraints, and analyzing risk communication aspects. Most of these approaches tend to frame seasonal climate forecasts as a discrete product with direct and linear effects. In contrast, the authors propose that agricultural management is a performative process, constituted by a combination of planning, experimentation, and improvisation and drawing on a mix of technical expertise, situated knowledge, cumulative experience, and intuitive skill as farmers navigate a myriad of risks in the pursuit of livelihood goals and economic opportunities. This study draws on ethnographic interviews conducted with 38 family farmers in southern Georgia, examining their livelihood goals and social values, strategies for managing risk, and interactions with weather and climate information, specifically their responses to seasonal climate forecasts. Findings highlight the social nature of information processing and risk management, indicating that both material conditions and value-based attitudes bear upon the ways farmers may integrate climate predictions into their agricultural management practices. These insights translate into specific recommendations that will enhance the salience, credibility, and legitimacy of seasonal climate forecasts among farmers and will promote the incorporation of such information into a skillful performance in the face of climate uncertainty.

1. Introduction

Translating climate forecasts into relevant knowledge for agricultural decision making requires sound, demand-driven science; timely and appropriate delivery; and responsive management systems. Understanding responsive management systems is particularly important, because they incorporate factors that cannot be controlled by those producing and disseminating scientific information (such as by redirecting the research agenda or fine-tuning the communication process). This paper highlights the human dimension of a particular agricultural system, that of family farmers of southern Georgia (United States), to elucidate how seasonal climate forecasts will interact with existing configurations of norms, values, meanings, and knowledge. Such contexts will affect how farmers perceive and respond to forecasts as they navigate a myriad of risks,
including those associated with climatic variability and change.

The 1998 El Niño had dramatic and often devastating effects and provided impetus to research the relationship between El Niño–Southern Oscillation (ENSO) and climate variability around the world (Cane 2000). Subsequent studies demonstrating correlations between ENSO-based climate variability and crop yields have generated considerable enthusiasm about the potential of ENSO-based climate predictions in agricultural risk management (Hansen et al. 1998; Phillips et al. 2001, 2002). Such seasonal climate forecasts provide information designed to help decision makers plan strategies to reduce risk and optimize gains. For example, agricultural systems are expected to benefit from seasonal climate forecasts because of the close link between climatic patterns and production outcomes (Hammer et al. 2001; Hansen 2002; Meinke and Stone 2005) and because of the vulnerability of rural communities, which lack economic resources and political power (Broad et al. 2002; Archer 2003; Lemos and Dilling 2007). In particular, climate forecasts can help increase agricultural production and food security where farmers tend to prefer risk-averse strategies that forego some potential gains in order to minimize the chance of catastrophic losses (Hansen 2002; Meza et al. 2008). The decade following the 1998 El Niño has seen a proliferation of studies to examine the implications of this new knowledge in agriculture and natural resource management. This body of literature has pursued three main directions.

One line of investigation, centered on agronomic and economic modeling, seeks to estimate the economic “value” of forecasts. This work includes “ex ante” research on potential benefits (Thornton 2006; Cabrera et al. 2007; Meza et al. 2008) and “ex post” analyses of actual impacts of decisions influenced by forecasts (Msangi et al. 2006). Agronomic and economic models indicate that, over time, adaptive use of seasonal climate forecasts could provide moderate benefits (Ash et al. 2007), although more so for farmers who face relatively minor risks rather than high risks (Letson et al. 2005). However, a recent study focused on high-risk semiarid farming systems in Kenya demonstrates that, with higher levels of predictability, value can be attained, at least for crop-specific decisions (rather than farm level; Hansen et al. 2009).

A second line of investigation is based on empirical research observing how farmers and other users integrate forecast information in their decision making and what factors may enable or hinder this process (for a review, see Roncoli 2006). Many of these studies have identified “potential” applications in areas where dissemination and/or awareness of forecasts is limited (Eakin 2000; Ingram et al. 2002; Luseno et al. 2003; Zierovogel and Calder 2003), whereas others have examined cases of actual use of predictive information in agriculture (Finan and Nelson 2001; Letson et al. 2001; Phillips et al. 2002; Archer 2003; Meinke et al. 2006; Broad and Orlove 2007; Hayman et al. 2007; Patt et al. 2008; Roncoli et al. 2009a). This research has shown that the relevance and utility of climate forecasts is influenced by various factors, including the extent to which forecast characteristics (prediction parameters, skill level, time frame, lead time, spatial scale, etc.) correspond to users’ needs and priorities; the ways forecast information is translated into messages and made available to users; and whether the necessary resources and policy supports are available to farmers, particularly those in developing countries.

Finally, a third line of investigation, inspired by risk communication theories and based on experimental work, focuses on the cognitive aspects of information processing, including the influence of prior experience, mental models, learning styles, etc. This work has demonstrated that different ways of framing probabilistic information, such as the types of language used, the reliance on statistical data or vivid imagery, or the delivery of information to individuals or in group settings, affects comprehension, perceptions, and attitudes among users (Nicholls 1999; Patt and Schrag 2003; Hansen and Indeje 2004; Hu et al. 2006; Marx et al. 2007). Consequently, a range of representational formats and dissemination approaches have been designed and tested to isolate factors that may result in errors, biases, mistrust, or apathy. They also promote ways of processing forecast information that foster better decisions (Suarez and Patt 2004; McCrea et al. 2005; Hansen et al. 2007; Roncoli et al. 2009a).

Despite their differences in focus, theory, and methods, many of these studies share a view of climate forecasts as an input to agricultural decision making with direct and linear affects. The assumption is that, once forecast value is demonstrated; content is customized to users’ needs, presented, and delivered appropriately; cognitive biases are eliminated; and adaptive strategies are supported by enabling conditions, such inputs will be “adopted” and climate variability risks will then be “managed.” But what exactly does management mean in agriculture? The term often implies a set of linear and mechanistic technical behaviors that are consciously planned out on the basis of predetermined parameters. However, such approaches to agricultural management take an overly rationalistic view of decision processes and a reified notion of technical solutions, which are understood more as products than as practices (Jansen 2009). What this misses, however, is the “performative” element of agriculture, in which farmers engage in creative problem solving.
in ways that draw on a dynamic repertoire of knowledge, skills, networks, and technologies contextualized in immediate social and biophysical conditions. Seen as performance, agricultural management is a blend of planning, experimentation, and circumstantial improvisation within an ever-shifting environment (Richards 1989, 1993; Batterbury 1996; Stone 2007). The result is a process whereby the dynamic external conditions and available resources form a basic structure within which farmers apply their skills at leveraging opportunities and minimizing risks. Any new technologies, in this case seasonal climate forecasts, must integrate into performative practices.

Farmers’ use of tacit know-how and practiced skills to adjust to variable circumstances does not preclude recourse to more codified systems, such as scientific climate information and other technical expertise (Batterbury 1996; Ellen and Harris 2000; Cleveland and Soleri 2007). In the face of climate uncertainty, farmers seek to reduce their vulnerability by using multiple forms of knowledge in combination with material technologies (e.g., irrigation systems, improved seeds, etc.), institutional supports (e.g., insurance, credit), and social networks (e.g., family, community, extension, markets, etc.). Conceptualizing agriculture as performance emphasizes that risks, such climate impacts, are embedded within a system of biophysical and socioeconomic processes that are constantly being navigated and negotiated by actors. Information, such as seasonal climate forecasts, is incorporated into agricultural performance as one element among many. This system encompasses decision drivers that fluctuate at time scales ranging from daily or seasonal (e.g., commodity prices) to multiyear (e.g., farm policies) to long term (e.g., climate change). But agricultural practice is equally grounded in a landscape of shared worldviews, social identities, moral values, and cultural norms (Jennings 2002; Burton 2004; Dessein and Nevens 2007; Neumann et al. 2007; Dyer and Bailey 2008). In this perspective, farming decisions acquire meanings and follow pathways that are far more complex than assumed when only considering agricultural productivity and economic rationality principles. Rather, they engage the farmer’s subjectivity and socialization in addition to his/her technical skills and resource endowment.

Assessing the potentials and limitations of risk management tools, such as seasonal climate forecasts, merits careful analysis of the dynamic and multidimensional milieu in which farmers pursue their livelihood goals. Research on the role of seasonal climate forecasts in agriculture has recognized the need for qualitative social science methods to complement and contextualize quantitative approaches and model-based analyses (Hansen 2002; Meinke and Stone 2005; Meza et al. 2008). Ethnographic and participatory approaches have contributed substantially to an understanding of how rural producers in developing countries incorporate climate predictions into their cultural and cognitive landscapes and decision-making processes (Roncoli 2006; Roncoli et al. 2006). Such approaches are all the more essential for an understanding of farming as performance and of how uncertain climate information may fit with the established ways whereby risk is understood and addressed by farmers.

In this paper, we present findings from ethnographic research aimed to elucidate farmers’ perspectives on seasonal climate forecasts and their implications for viability of farming enterprises. This study complements the previously mentioned bodies of literature by emphasizing what matters to and motivates farmers and how they themselves value what forecasts may contribute to their endeavors and aspirations, how farmers see themselves dealing with climate risk in the context of a wide array of other worries and pressures, and how farmers respond to the communication of predictive information in light of their sense of place and sense of self. The insights emerging from the analysis of farmers’ own discourses will inform efforts to convey probabilistic climate information in a manner that helps farmers integrate it, with the right mix of confidence and caution, into the planning and performance of their agricultural strategies.

2. Methodology and sample characteristics

This study was conducted under the auspices of the Southeast Climate Consortium (SECC), a multidisciplinary research project dedicated to developing climate-based risk management tools for crop, livestock, forestry, and water resource management in the southeastern United States. This region is among those recognized as an ideal test bed for climate applications, given the prominent role of agriculture, the climate sensitivity of its main crops, and the correspondence of agricultural activities with climate patterns (Garbrecht and Schneider 2007). The decision support system in question is centered on seasonal climate forecasts of climate trends based on correlations between sea surface temperatures (SSTs) in the Pacific Ocean and seasonal climate variability, the phenomenon known as the El Niño–Southern Oscillation (Piechota and Thomas 1996; Goddard et al. 2001). For example, El Niño conditions (characterized by above-average Pacific SSTs) typically bring more rainfall and cooler temperatures to the southeastern United States in the fall and winter months, whereas the La Niña phase (characterized by below-average pacific SSTs) brings warmer and much drier conditions in the
fall, winter, and spring (Baigorria et al. 2008). Neutral years are characterized by greater frequency of winter freezes. The SECC’s main outreach mechanism is an interactive Web site (available online at http://www.agroclimate.org), which provides seasonal climate outlooks and agricultural decision support tools (Fraisse et al. 2006). Central to the SECC approach is the integration of stakeholder input into research agendas and tool development and the involvement of agricultural extension in its assessment and outreach efforts (Jagtap et al. 2002; Breuer et al. 2008; Cabrera et al. 2008).

The findings are based on 31 semistructured interviews with a total of 38 farmers, conducted between December 2006 and March 2007 (7 interviews were conducted with two farmers at a time), building on preliminary interviews with 8 farmers in January 2006. The fieldwork covered 21 counties, which represent the diversity of agroecological regions and production systems across southern Georgia, an area characterized by a stronger ENSO effect on seasonal climate variability than the northern part of the state (Fig. 1). The research design used a nonrandom sample comprised of farmers who were willing to spend about one hour discussing their farm operations and management strategies with the research team. Participants were contacted through the agricultural extension service, which plays a key role in the SECC, mediating communication between scientists and stakeholders and disseminating the information produced by the SECC tools. In 13 counties, extension agents themselves were present during the interviews and occasionally intervened in the discussion. This was unavoidable, given that agents played key roles in introducing researchers and farmers and in organizing the interviews, which were often conducted in the county extension office and purposely followed a conversational style. Although their involvement in interviews may cause legitimate concern about the possibility of biasing farmers’ responses, it was also found to be helpful, because extension agents are familiar and trusted actors in the local scene. Most of them are from farming backgrounds in nearby counties and some had previously managed farm operations. Therefore, their insights have been included in the analysis where relevant.

The interview protocol was designed to elicit information on farmers’ production systems, climate-sensitive management decisions, use of weather and climate information systems, and potential application of seasonal climate forecasts. This protocol was loosely followed, allowing the conversation to be partly guided by the thought process of the interviewees. Such an approach is crucial, because it allows the discussion to go beyond simple dichotomies (e.g., use/not use, trust/not trust) to elicit a more qualified (e.g., how, why, to what extent) understanding of the role of predictive information in management decisions (Hayman et al. 2007). The open-ended nature of the interview also permits unanticipated salient issues and insights to emerge spontaneously. This, however, results in a dataset where not all topics are necessarily covered by every interviewee, thus somewhat limiting the quantitative analysis. Although we present quantitative data for some basic questions, our emphasis remains on the qualitative aspects of the research. Interviews were audio-recorded, transcribed, and analyzed thematically using NVivo software (QSR International).

Most interviewees are middle-aged men, as is typical of most farm operators in southern Georgia. There was
only one female interviewee, who had established an organic produce operation on family land as a second career. The vast majority of farmers interviewed were over 40 yr old, though the sample included three farmers in their 20s, who were from farming families and had decided to take up farming after finishing college. Educational levels among farmers interviewed ranged from high school to four-year university degrees in business or agricultural sciences. The majority of interviewees were Caucasian, although two were African American. This was because the latter group is often very small-scale, part-time operators, whereas most farmers who are closely associated with extension, and therefore more likely to be recruited as research participants, tend to be full-time and larger-scale farmers.

By design, a broad spectrum of production systems found in southern Georgia is represented (Table 1). Operations vary from single-sector enterprises to combinations of several production systems, with an average of two sectors per operation. For row crops, the percentage of irrigated land ranges between 0% and 75%, whereas fruit and vegetable operations are entirely irrigated. Most interviewees come from families that have been farming in the same area for several generations. As is typical for southern Georgia, farmers managed a combination of owned and rented fields, with farm sizes ranging from about 100 to 8000 acres. The majority (87%) of the farmers interviewed describe themselves as full-time farmers, whereas a minority integrates farming into a diversified livelihood, which includes involvement in farm-related businesses or nonfarm employment.

Family farming in Georgia, as in much of the world, is a collective endeavor. Most (54%) of the farmers interviewed viewed own or operate their farms in partnership with other male family members. Typically, in multifamily arrangements, individuals specialize in different areas, such as crop management, labor supervision, equipment maintenance, marketing, and finance, but key decisions are made in common. As noted in other studies of family farming (Barlett 1993; Hu et al. 2006; Breuer et al. 2008), most full-time farmers have a spouse who is employed outside the farm or runs a separate business. The spouse’s health insurance and extra income contribute to the farm enterprise by reducing costs and smoothing out fluctuations in earnings associated with the farm economy. Generally more computer literate than farmers themselves, wives often keep accounts and inventories and do bank and insurance paperwork.

Despite the diversity of production systems and partnership arrangements described here, farmers’ discussions of risk management reflect a common set of attitudes and aspirations. This value system defines farmers as a community even though, as is the case with all communities, they are internally differentiated in terms of their resource base and adaptive capacities. We recognize that the role of extension in recruiting interviewees may have biased the sample toward those farmers who are more likely to be familiar with or responsive to the agents. Likewise, some degree of self-selection occurred based on the research topic itself. For example, farmers with most of their land under irrigation and owners of very large operations, who often rely on private providers for information and technical services, were less interested in meeting with the research team. On the other hand, farmers with most of their operations on dry land were more eager to participate and constituted 70% of the sample. Among row crop farmers in the sample, an average of 34% of land is under irrigation, ranging from 0% to 70%. Because of their dependence on rainfall for their livelihood, these farmers are highly attuned to weather and climate variation and generally more interested in predictive information.

Given our reliance on a purposive sample, we do not propose that the findings of this study can be generalized to all farmers in the region. Rather, our objective was to elicit rich qualitative data regarding farmers’ perceptions of vulnerability, their risk management strategies, and the potential role of seasonal climate forecasts, all in the context of their livelihood goals and practical knowledge. We knowingly traded off generalizable statistical results for an approach that elicits a more nuanced and textured understanding of the complexities of farmers’ decision-making processes, including the systems of meanings and relationships that tie together stakeholders, technologies, information, production systems, and natural environments (Roncoli et al. 2009b).

<table>
<thead>
<tr>
<th>Production system</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row crops</td>
<td>32</td>
</tr>
<tr>
<td>Fresh produce</td>
<td>11</td>
</tr>
<tr>
<td>Cattle</td>
<td>8</td>
</tr>
<tr>
<td>Pine plantation</td>
<td>8</td>
</tr>
<tr>
<td>Hay</td>
<td>5</td>
</tr>
<tr>
<td>Pecans</td>
<td>4</td>
</tr>
<tr>
<td>Sows</td>
<td>2</td>
</tr>
<tr>
<td>Turf grass</td>
<td>2</td>
</tr>
<tr>
<td>Poultry</td>
<td>2</td>
</tr>
<tr>
<td>Goats</td>
<td>1</td>
</tr>
</tbody>
</table>

1 Dry grains and storable commodities, which are typically grown at large scale and have relatively lower profit margins, as distinguished from fresh fruits and vegetables. In this case, the most common row crops are peanuts and cotton, with small amounts of maize, soybean, and wheat.
Following our research design, the presentation of results intentionally emphasizes farmers’ voices by using excerpts from interview transcriptions, recognizing that discursive style is instrumental to conveying the richness and vibrancy of lived experience (Burton 2004; Shepherd et al. 2006; Sharman 2007; Carolan 2008). The presentation of research findings is articulated in terms of four overarching themes that emerged from the interview transcripts, elucidating how farmers articulate the goals and values that animate their work, how farmers strive to hold on to their land and lifestyle by minimizing risk and pursuing opportunities, how farmers interact with the information environment relative to weather and climate, and how farmers envision and in a few cases have experimented with using climate forecasts in their decision making.

3. Research findings

a. Livelihood goals and cultural values

It is now well recognized that subjective and social dimensions play key roles in shaping resilience and defining which adaptive options are deemed acceptable or feasible (Adger et al. 2009; O’Brien 2009). To understand how farmers might use climate information to manage risk, we begin by briefly examining the overall landscape of personal values and livelihood goals within which the technical management of risk is situated. Although farmers often refer to “making a crop” (producing enough to cover their costs) as their basic aim, their decisions integrate sociocultural and economic considerations. For example, one farmer explained his cropping choices in terms of his preference for a relaxed and independent lifestyle as well as his intention to minimize the risk of losing money or yields:

But I don’t like to grow cotton. It’s too expensive, too labor intensive. Without me being there all day. I like to farm and I like to save money and do it cheaply, and I like to have time off on the weekends to do the fun things in life. (Farmer 9)

In explaining their decision to make a living from farming, despite the associated costs and risks, interviewees stress the pleasure of working outdoors, the autonomy of being self-employed, and the ability to take time off for hunting and fishing when the farming season is over. They also emphasize the close connection between rural life, family values, and moral character:

I think it’s a great place to raise the kids, because we see that they work so they develop a work ethic very young. We still have our independence, I suppose. I think for the most part, at least in this part of the state, farmers are good, moral people and good people to deal with and good people to be around. It’s just a good life. As long as it all works, as long as you can make a living at it. (Farmer 19)

Even though farmers refer to their operation as a “business,” the need for money is often rationalized in terms of being a good provider for one’s family and honorable member of the community. Managing profitable farm enterprises is also a way of ensuring the continuity of family farms. It has been well documented since the farm crisis of the 1980s that farm foreclosure is not simply an indicator of economic failure; rather, it has profound emotional and social implications for farmers, particularly when they are forced to sell family land or home equity (Barlett 1993; O’Brien et al. 1994; Hoyt et al. 1995). “Keeping land in the family” is a recurring theme in farmers’ discussions of their production strategies. This goal links past, present, and future generations, expressing respect for forebears who have previously tended the land and demanding that current owners manage it wisely and transmit it to their children. Retaining land ownership, however, is increasingly difficult in an environment of rising costs, fluctuating prices, and recurrent droughts. Although farmers want to pass their land on to their children, they are split on whether they want their children to go into farming. The 12 farmers who addressed this question indicated conflicted positions. Half of these farmers stated that they would rather encourage their children to pursue higher education and stable employment because of the hardships and uncertainties associated with making a living as a farmer. Yet, it was with pride that the other half of the farmers reported that their “hard headed” sons were committed to, or at least considering, staying in agriculture, in some cases against their advice. Often these accounts culminated in references to farming being something that “gets in your blood” and cannot be left behind, as in the following comment:

I’ve been trying to talk [my son] out of it. But if he’s like me and got it in him, everybody in Georgia couldn’t talk him out of it. It’s a battle to farm. You got to love it, or don’t mess with it. (Farmer 4)

This deliberation process, whereby a young man decides to either abandon or embrace farming, is framed as a rite of passage, which the farmers themselves had undergone in their own youth. (“My granddaddy tried to talk me out of it because of the changes he had seen.”) The commitment to farming as a livelihood and a lifestyle implicitly entails an acceptance of living and working in an environment characterized by a high degree of risk because of the vagaries of climate, markets, and policy among other things. Vulnerability is further magnified by the high capital investments and heavy
debt burdens that have been required to make a farm operation viable. Risk management is therefore not simply a technical calculation, it is central to farmers’ ability to hold on to their land, their lifestyle, and their sense of self. Even when not explicitly articulated in farmers’ accounts of agricultural decisions, these values epitomize the high stakes farmers have in risk management, as well as the deep-seated meanings and far-reaching aspirations that may be destabilized by potential yield or income losses.

b. Risk management strategies

Risk management among farmers in the region hinges on a variable blend of planning and performance, both grounded in past experience and aspirations for the future. Barlett’s (1993) seminal study of family farms in Dodge County, in the coastal plain of central Georgia, examines the human dimensions of the severe crisis that affected the farm economy in the 1980s, forcing as many as one-third of full-time family farm operations out of business. The farm crisis, which coincided with the devastating effects of prolonged drought, induced new attitudes toward livelihood goals and risk management, toward greater conservatism and risk aversion. It also ushered in several key risk mitigation mechanisms (pivot irrigation, crop insurance, government payments, and off-farm working spouses), through which southern Georgia farmers currently cope with the effects of climate variability.

An understanding of agriculture as characterized by unavoidable uncertainties is a cornerstone of farmers’ discussions about how they make decisions. The farmers in this study all recognize that they cannot manage their operations in ways that entirely eliminate risk, instead they construe risk management in a temporal framing of failure and success that goes beyond a single season to encompass many years. Acknowledging that occasional bad years are inevitable, farmers develop expectations based on personal and collective experience. (“With dryland corn, probably you are going to make it in 7 out of 10 years.”) Therefore, Georgia farmers employ management strategies that have good chances of ensuring some yield during most years and under most conditions, as do producers in other climate-sensitive regions of the world (Eakin 2000; Batterbury 2001; Ingram et al. 2002; Lemos et al. 2002; Luseno et al. 2003). The rationale for this approach is that consistency eventually pays off and that, in the long run, it is safer than trying to adjust cropping patterns seasonally to maximize short-term gain. The following statement exemplifies this long-term perspective on climate uncertainty and agricultural outcomes, supported by overall confidence in farming as a viable livelihood option:

To have the true average, for us, and really for farming at all, you need to be consistent and do the same thing. It’s gonna be hot, it’s gonna be dry, it’s gonna rain, and it’s gonna rain a lot. Without knowing specifically when events will happen, your faith in God has to be the overruling factor in all of it. And you know it’s all gonna work. If you do your job and the rest of it will take care itself. You’re gonna have good times, you’re gonna have bad times, you’re gonna make good crops, you’re gonna make not so good crops. That’s the way it’s been since the beginning of time and I think that’s the way it’s gonna be.

(Farmer 21)

As with rural producers in other parts of the world, diversification is also a key strategy employed by Georgia farmers to manage environmental and climate risk. Having fields in various locations allows the exploitation of microlevel variation in soil types and rainfall conditions. Planting different crops and varieties also spreads risks over different operations:

We have to take all of it in an average. You can’t say we made a lot of money in the watermelons and nothing over here. You have to kind of average it all together . . . Take the good with the bad. Maybe one year it will all be real good. Good watermelon, good cotton, good peanuts.

(Farmer 7)

In addition to diversification of holding and cropping systems, farmers use irrigation in an attempt to reduce their exposure to climate risk. Availability of irrigated land heavily influences what crops farmers grow. For example, peanut and corn are often planted on irrigated land, whereas cotton, being more drought tolerant, is generally grown on unirrigated land. But, although irrigation can increase yields and buffer from losses, it also is expensive to install and operate (most irrigation systems run on diesel, so rising fuel costs impact profit margins). Therefore, although some farmers rely on irrigation to control a crop’s entire water regime, others seek to contain costs by using irrigation to “fill in” between rains. The following passage highlights the contrast between these two strategies and the close link between irrigation choices and risk perceptions:

Well, as uncertain as climate had been, it’s been flip-flopping with all the talk of El Niño and La Niña and all, irrigation is something to fall back on. I made the best corn under irrigation last year that I’ve ever grown, and I only watered it 5 times. I talked to some people who watered corn 8 or 10 times, and they made good corn, but they had a lot more [money invested] in their crop, and, with irrigation, if you’ve got to do it from start to finish it will be expensive, but if you can have irrigation to fill in between rains, that’s where I see irrigation really paying off.

(Farmer 34)
Crop insurance is another risk management tool that guarantees farmers a minimum financial return on their crop. Farmers, especially those with row crops planted in unirrigated land, opt for the highest level of insurance they can get and still afford, with coverage ranging between 50% and 75% of their established average yields. Availability of different insurance products may influence crop choices, because coverage may be more favorable for some crops (i.e., corn) than for others (i.e., cotton). For example, in most areas insurance is not yet available for some crops that are profitable, but highly vulnerable to climate stress, such as blackberry, watermelon, or sweet corn. Insurance provisions shape farmers’ agricultural strategies, because insurance contracts have clauses that require farmers to follow certain practices, such as planting dates and input applications. These conditions are meant to reduce the risk faced by the insurer, but they simultaneously constrain farmers’ flexibility in responding to climate conditions (e.g., by re-planting later in the season if a crop fails to establish).

Although farmers use these strategies and mechanisms to manage climate risk, there are many other factors that influence choices. Agroecological conditions and crop rotation schedules are key parameters for seasonal planting strategies, but commodity prices remain the primary drivers of management decisions. Among row crops, prices for cotton and peanut have stagnated, whereas recent ethanol-driven boom in maize prices (which coincided with this research) had created incentives for farmers to plant more maize, often replacing peanuts. But the incentive of high prices was balanced against other drivers, such as the availability of irrigated land and specialized harvesting equipment, as well as financial supports for different crops (insurance, loans, and government payments). The heavy financial investment in equipment and infrastructure (such as cotton combines or grain storage facilities) also reduces farmers’ flexibility to respond to changing conditions. As one farmer stated, “I got land rented, I got land bought, I got tractors bought and leased, I got people working for me, I can’t just say I’m not going to farm this year because they are predicting a bad year.”

In sum, although farmers routinely deploy ways of dealing with climate risk, they operate in a decision-making environment that is conditioned by a host of other agronomic, economic, institutional, and policy-related uncertainties and influences, some of which may override climate considerations. The interaction of these factors will shape whether and how seasonal climate forecasts will be integrated in farmers’ decisions and practices.

c. Weather and climate information environment

Elucidating the social processes whereby scientific information is accessed and processed is essential to understanding how such information is assimilated into the knowledge base that supports adaptive adjustments in agricultural planning and performance. These processes are mediated by technologies and networks of information delivery, which are key factors in constructing the credibility and legitimacy of climate prediction (Cash et al. 2006; Meinke et al. 2006). Research shows that attitudes toward climate predictions, including beliefs and feelings, are as important as comprehension in influencing whether farmers’ use the information (McCrea et al. 2005). Such attitudes are grounded in personal experience (as when someone has suffered losses because of a “wrong” forecast) but also in the way people relate culturally and socially to the means and the messengers that deliver predictive information (Sherman-Morris 2005).

Table 2 indicates the frequency of reference to sources of scientific forecasts, with television being the most common, followed by the online Web sites. In addition, five farmers, mostly elderly, mentioned the Farmer’s Almanac and folk knowledge based on environmental

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**Table 2. Farmers’ sources for weather and climate information.**

<table>
<thead>
<tr>
<th>Source</th>
<th>Frequency</th>
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</thead>
<tbody>
<tr>
<td>Weather Channel (TV)</td>
<td>21</td>
</tr>
<tr>
<td>Local TV</td>
<td>19</td>
</tr>
<tr>
<td>DTN</td>
<td>10</td>
</tr>
<tr>
<td>Online (commercial)*</td>
<td>11</td>
</tr>
<tr>
<td>Print media</td>
<td>7</td>
</tr>
<tr>
<td>Online (public)**</td>
<td>6</td>
</tr>
<tr>
<td>Cell phones</td>
<td>4</td>
</tr>
<tr>
<td>Local radio</td>
<td>3</td>
</tr>
<tr>
<td>Online (unspecified)</td>
<td>1</td>
</tr>
</tbody>
</table>

** National Weather Service, National Oceanic and Atmospheric Administration, Georgia Automated Environmental Monitoring Network.
indicators. The latter includes the belief, voiced independently and spontaneously by three farmers, that years with 13 full moons tend to be drier than normal. This is one area that might have been influenced by the role of extension in participant recruitment and interviews. Because extension services are perceived as channels for modern technology and scientific knowledge, farmers may have overlooked or refrained from considering traditional knowledge in their discussions. Interviewees reported using an average of three sources of information, not including interpersonal exchanges. This process of triangulation, whereby farmers cross-check information from different sources and from their observations, is exemplified by the following comment:

We probably spend, during planting season on through harvest season, probably an hour a day watching weather. In the morning, at dinner time, at night when we come in, our wives watch it. I’ve got mine trained “At 6:12 you watch the weather on TV.” Sometimes, I have had her hold the phone up to the TV. Between the DTN, and the telephone, and the television, and the computer … some days I have all three or four going on at the same time; because each one has a kind of different twist on things and you’ve got to average them out. We spend a tremendous amount of time watching weather. (Farmer 25)

This passage also highlights the centrality of social networks for the processing of information. Weather and climate are often discussed with other farmers at social gatherings; with extension agents during farmer meetings; and with suppliers, buyers, and brokers during business transactions. Larger operations also hire consultants for crop management and marketing services, who provide access to DTN and other sources of information. Given their roles in conveying information and guiding decisions, these consultants may play key roles in forecast dissemination and are being targeted by the SECC outreach efforts.

Farmers’ wives and children act as conduits for information gathered from online sources, as also found in other regions (Hu et al. 2006; Breuer et al. 2008). Although 50% of the farmers mention using online weather information sources, 40% of those specify that their wife or children are the ones who actually navigate the computer. In addition to poor computer literacy among older generations, farmers often have limited time and mental energy to search for and process additional information. Farmers are, in fact, involved in countless day-to-day tasks, such as managing crops, inputs, labor, equipment, marketing, and finances. This burden has been intensified by the increasing technological sophistication of agriculture, as well as by the expansion in paperwork required by lending agencies, insurance companies, government program, and labor laws.

Although farmers are highly attuned to weather forecasts, their use of such information is hindered by doubts about the information’s relevance and accuracy. Even while acknowledging that weather forecasting has improved considerably, farmers’ discourse is characterized by many jokes about the unreliability of weather forecasts. Two basic criteria in farmers’ assessment of the reliability of weather and climate information are its temporal frame (“That’s a scientific wild guess, when you go past, in my opinion, a week. They do a good job at 24 hours, they do a fair job at 48 hours …”) and its spatial scale (“I think channel 6 is more reliable. Of course I live closer to them, to their station, so it works for me.”). In part, the skepticism toward forecasting stems from farmers’ perception of urban bias on the part of mass-market outlets, such as network and cable television, which are oriented toward larger audiences in cities where the TV stations are based. An urban bias represents both an operational issue, in terms of the geographic specificity of forecasts, as well as an issue of social relations and identity. Farmers’ discourse is infused with a view of rural (southern) Georgia as a different world than the one inhabited by producers of television programs “up in Atlanta.” The use of scientific or foreign terminology in climate reporting also exacerbates farmers’ feeling of alienation from the priorities and discourses of urban-based media. (“A lot folks around here often wonder where these Spanish names came from: El Niño and La Niña. It used to just cloud up and rain.”)

Among interviewed farmers, 40% do not clearly distinguish between “climate” and “weather,” often using the terms interchangeably. This is important, because it indicates that attitudes toward ENSO-based seasonal climate forecasts are influenced by their perceptions of weather forecasts. Only 32% of the interviewees reported receiving seasonal climate forecasts, except in the case of hurricanes. Georgia farmers often depend on rain storms brought by late summer hurricanes to bring their crops to maturity. Some 18% of the interviewees recounted that an active hurricane season had been inaccurately forecast in 2006 and cited this as a reason for not trusting long-range forecasts. One farmer comments on the danger of relying on such predictions for planning purposes:

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2 Data Transmission Network (DTN) is a private company that disseminates agricultural information, such as commodity prices and weather reports. DTN is a pay service with proprietary hardware, which is often located at supply stores, crop-buying points, or county agricultural extension offices, though some large operators have their own DTN machines.
Last year, the NWS was saying “We’re going to have more hurricanes than ever!” So people were planning “Well, we’re going to get some rain,” and we didn’t. There were very few hurricanes and the rain didn’t come through with them. And you can’t plan ahead and then have the weather service mess you up. (Farmer 32)

Unlike short-term forecasts, farmers interviewed are not in the habit of actively seeking seasonal climate forecasts for use in management decisions. Instead, 90-day climate forecasts are occasionally encountered in the farm press, mainstream media, or DTNs. Of the 12 farmers who acknowledged encountering seasonal climate forecasts, only one mentioned using it, responding to a hurricane season forecast, not an ENSO-based forecast such as those produced by the SECC. The other 11 farmers typically say that, although the forecasts do not influence their decisions, they appreciate having the additional information:

[A 90-day forecast] is great for peace of mind and we love it, but we can’t put a whole lot of stock in it because it is not site specific. It [just] says “The Southeast is going to be abnormally dry.” (Farmer 25)

In addition to farmers’ ambivalence and unfamiliarity with seasonal climate forecasts, the mismatch between what the science offers and what farmers need to know also hinders their use in decision making. As also found in other studies of climate applications in agriculture (Phillips et al. 2001; Ingram et al. 2002; Lemos et al. 2002; Luseno et al. 2003; Ziervogel and Calder 2003; Klopper et al. 2006), the timing and distribution of rainfall events, particularly during periods when crops are most vulnerable, is more useful information than a relative measure of total quantity of seasonal rainfall, such as that provided by ENSO-based seasonal climate forecasts. For example, produce farmers want to know about the specific dates of late freeze events, whereas row crop farmers are interested in precipitation patterns in June and July, so that they can choose what and when to plant in the spring. The lead time of forecast delivery is equally important, because many production decisions that may be affected are made well ahead of the planting season. For example, many farmers approach banks for loans in January and in doing so they must submit a farm plan. Farmers also arrange for seed purchases as early as possible (January–February) to make sure they can get their preferred varieties.

Even more than forecast parameters and lead time, the forecasts’ past performance emerges as a key issue, mentioned by most (92%) of farmers interviewed, for determining whether they would consider trusting and using the information. Lack of accuracy and reliability were, in fact, the most frequently cited reasons for not using seasonal climate forecasts by farmers in Australia, where seasonal climate forecasts are routinely disseminated (Hayman et al. 2007). The ability of tracking how well the forecasts represents the actual climate and the provision of histories of previous forecasts have been recognized as key prerequisites by assessments of the potential of seasonal climate forecasts for agriculture (Meinke and Stone 2005). But what makes up a forecast’s past performance remains an open question, even among scientists. There are different approaches to determining forecast “skill” as well as to assessing forecast quality, value, and outcomes (Meinke and Stone 2005; Thornton 2006; Ash et al. 2007). In addition, farmers’ perceptions of accuracy diverge from those of scientists, being rather based on the degree of fit between a predicted scenario and observations and experiences in the context of their agricultural operations, an understanding that must qualify efforts to establish accuracy thresholds for trusting and adopting forecasts (Ziervogel et al. 2005; Ash et al. 2007; Breuer et al. 2008). In sum, moving seasonal climate forecasts from a “conversation piece” to a risk-management tool requires not only assimilating them into farmers’ habitual information flows but also framing forecasts in ways that allow for learning and judgment in farmers’ own terms.

d. Applications of seasonal climate forecasts

The central role of personal experience in farmers’ agricultural performance and adaptive learning means that interviewees were initially puzzled when asked to identify potential responses to information that they had never before encountered. Nonetheless, after having been presented with the climate outlook for the 2007 spring season, the interviewees enumerated several potential forecast applications, consistent with findings from the southeast United States (Breuer et al. 2008) and elsewhere in the world (Phillips et al. 2001; Ingram et al. 2002; Ziervogel 2004). Changing crops and crop varieties were among the most commonly mentioned forecast uses (Table 3). For example, a climate outlook based on La Niña conditions (which are associated with a drier, warmer spring) may prompt row crop farmers to plant more drought- and heat-tolerant crops (cotton, soybean, wheat) rather than corn or peanut. Farmers may also choose crops that enjoy better insurance guarantees and government support. The second most common use mentioned is modification in planting time: for example, with a forecast for a dry spring, farmers could delay planting to minimize risk of losing seedlings to drought and plant shorter cycle varieties to make up for the delay. Farmers may also upgrade their insurance coverage and reduce production costs to compensate for lower yields and revenues. They would need to make
sure that irrigation equipment is in order and cash is available to buy the additional fuel needed. Land use responses to a drought forecast include planting in lower areas, leaving marginally productive fields unplanted, and renting out excess land. A drought forecast may also influence marketing strategies, such as waiting to sign contracts in anticipation of a possible yield shortfall or price hike. Owners of pine plantations may decide not to plant new trees (especially long leaf pine) and to leave needles on the ground, rather than harvesting them, to conserve soil moisture. If warmer than normal temperatures are expected, managers of poultry and hog facilities would need to check ventilation systems and hire more labor for monitoring. If higher than average rainfall is predicted, hog waste lagoons would need to be partially emptied out in advance to prevent overflowing and adjust to lower absorbing capacity of soils (for more detail on forecast responses, see Crane et al. 2008).

In addition to their role in mitigating climate risk, some farmers observed that climate forecasts could be perhaps even more useful in capitalizing on favorable conditions, as also found by research conducted in other parts of the world (Phillips et al. 2002; Roncoli et al. 2003, 2009a). For example, if higher than average rainfall was predicted, farmers with both irrigated and unirrigated land could expand planting into marginal dryland fields, freeing irrigated land for higher value but climate-sensitive crops. Furthermore, farmers interviewed recognized that climate predictions may allow them to maximize competitive advantage. One farmer with an electrically operated irrigation system commented that, if a drought was predicted, he might purposely plant water-demanding crops. This would enable him to exploit the advantage that an irrigation system that is cheaper to operate gives him over other farmers who, in a drought situation, may have to limit irrigation to contain their diesel fuel costs and consequently suffer yield reductions. A reduced supply would lead to better prices, increasing the revenues of those farmers with those crops for sale. Other farmers stressed that unfavorable climatic conditions may actually benefit them: “I’d rather have a poor crop and a good price than a good crop and a low price,” because reduced yields would mean not only greater revenues but also lower costs for harvesting, packing, etc. This is especially true for produce, which has a more regional and volatile market than row crops. Similarly, the anticipated effects of climate variability on resource availability can be used to advantage on pine plantations:

In pine, if you know it was going to get wet, and you have some wood on high ground, and it can be cut any time, you might want to hold off your timber sale until it gets wet and they can’t cut everywhere. You can do that because you know there is going to be a price spike. You wait until it gets wet and then you sell when the price goes up, if it didn’t matter to you when you make a sale. (Farmer 24)

Although dissemination of the SECC climate outlooks and tools is too recent for widespread impacts, this study found at least anecdotal evidence of their use. In January 2006, the SECC issued a forecast based on La Niña conditions. This forecast was distributed to agricultural extension agents across Georgia, and one of them included the forecast in his weekly column in the local newspaper, along with the recommendation that farmers consider growing the drought-resistant peanuts variety (02-C) instead of the more common, higher-yielding Georgia Green variety. The agent later reported that many county farmers who normally did not irrigate their land followed his advice and thus avoided yield losses resulting from the ensuing drought. However, given the complexity of real-life decisions, statistically distinguishing the specific effect of climate information from other decision drivers remains a challenge (Moser 2009). A farmer’s lengthy account of his response to a seasonal climate forecast illustrates the multivariate nature of forecast application, being influenced by factors such as land quality, availability of irrigation and equipment, production costs, commodity prices, and climatic conditions in competing regions:

Well, I am going to plant a little more dryland corn than what I had anticipated because when I went to the Cattle Fax, the national cattlemen’s convention, they had a meteorologist who gave us a 15 minute talk. He indicated that in this area we would probably have normal rain patterns. West of us they called for less than normal rain, like a light drought. But certain parts of the country are going to have a drought and that means corn prices should remain high because their production will be down. They haven’t had enough snowfall in some of the grain producing areas, so their soil moisture is not going

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**TABLE 3. Potential applications of seasonal climate forecasts as identified by farmers.**

<table>
<thead>
<tr>
<th>Decision with potential to be influenced</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop selection</td>
<td>23</td>
</tr>
<tr>
<td>Planting timing</td>
<td>16</td>
</tr>
<tr>
<td>Input management</td>
<td>14</td>
</tr>
<tr>
<td>Land management</td>
<td>13</td>
</tr>
<tr>
<td>Variety selection</td>
<td>11</td>
</tr>
<tr>
<td>Marketing strategy</td>
<td>8</td>
</tr>
<tr>
<td>Harvesting schedule</td>
<td>4</td>
</tr>
<tr>
<td>Insurance strategy</td>
<td>3</td>
</tr>
<tr>
<td>Cattle herd management</td>
<td>2</td>
</tr>
<tr>
<td>Hog lagoon management</td>
<td>1</td>
</tr>
</tbody>
</table>
to be near where it needs to be. Because of that I am
going to plant a little bit more corn, and then maybe I
would have another 20%, or 40 acres, of dry (unirrigated)
land. I was trying to decide between cotton and corn on
a good piece of land without irrigation and I decided to go
with corn and hope for the best. It’s basically because
your inputs are less with corn. I harvest the corn myself
with my own combine so my harvesting cost would be
significantly less than what it would cost to hire a custom
harvester to do my cotton picking. And the cotton market
doesn’t look any better than it did last year. I give equal
weight to the forecast for this area as I do for the other
corn producing areas. They’re going to have less than
adequate weather, and we’re going to have at least ade-
quate weather, and the price is up there, anyway. And the
price of cotton is not looking so great. (Farmer 16)

Even as they recognized a wide range of practical
applications of seasonal climate forecasts, farmers do
not necessarily consider the availability of such infor-
mation as an unqualified advantage, understanding that
other actors in the agricultural sector may use it against
their interests. This is especially an issue in the case of
large scale commercial actors who are better able than
individual farmers to seek, assess, and act on scientific
information:

Farmers don’t have time to research this stuff. Shellers,
who are trying to make a living, are playing a chess game
with a grower about price and all that, may hire someone
just to follow the weather. It’s a matter of amount of time
you got to work on it. I guarantee you that if it became
known that [a seasonal climate forecast] was available,
farmers would not be the only ones using it. The farmer
is not on a level playing field with everyone else. (Extension
Agent 7)

Evidence from elsewhere indicates that unequal ac-
to access to seasonal climate forecasts, as well as unequal
capacity to optimally respond, can indeed place rural
producers at disadvantage vis-à-vis more powerful stake-
holders (Broad et al. 2002; Lemos and Dilling 2007). For
example, commodity brokers and buyers may adjust
prices offered to farmers in advance contracts according
to predicted fluctuations in supply and demand caused
by climate patterns. Wholesalers may take their business
elsewhere if they expect that adverse seasonal climate
may lead to lower produce quality or reliability of sup-
plies. Farmers fear that input distributors may increase
prices if they have reason to believe that certain prod-
ucts (e.g., herbicides or pesticides) may be in greater
demand because of humid or dry conditions. Likewise,
insurance companies may adjust contracts and premium
rates in response to forecasts (see Cabrera et al. 2007 for
an analysis of the implications of climate variability and
forecasting for farmers’ and insurers’ contrasting inter-
est). There is evidence that lending institutions may
refuse credit to farmers following a prediction for a poor
rainy season (Hammer et al. 2001; Lemos et al. 2002).
Referring to a similar forecast, one of the farmers in-
terviewed remarked: “That’s scary: [the banks] may tell
me to sit this one out,” emphasizing the power that fi-
nancial institutions have over farmers’ risk-management
practices.

To summarize, farmers simultaneously consider many
variables: biophysical, social, and economic; personal,
local, national, and international; and empirical and nor-
mative. Navigating such dynamic cross-currents requires
the integration of myriad streams of information. Our
findings indicate that information tools such as seasonal
climate forecasts will not be embraced automatically or
uncritically. Instead, they are likely to be approached
cautiously, examined carefully, and experimented with
over time. This process will then be translated into gradual
and tactical adaptations and eventually integrated with
the other forms of knowledge and practice that consti-
tute agricultural performance and decision making un-
der conditions of uncertainty.

4. Discussion and conclusions

Analysis of farming as skilled performance—which
integrates practical knowledge, technologies, informa-
tion, social networks, and normative values—rather than
as mechanical deployment of technical solutions has
profound implications for climate applications and de-
cision support systems for agriculture. This is particu-
larly true, because farmers are increasingly involved in
the development of technologies and decision support
systems. The old linear “technology transfer” models,
wherein technologies are developed by specialists work-
ing in research facilities and then delivered to users by
extension, are being replaced by “coproduction” and
“end to end” approaches centered on expert and non-
expert collaboration (Cash et al. 2006; Hayman et al.
2007; Romsdahl and Pyke 2009). Proponents of these
approaches, including the Southeast Climate Consortium,
contend that a user-oriented, demand-driven research
process is essential to translating climate predictions
into “actionable knowledge” or “usable science” and
consequently into societal benefits (Vogel 2000; Archer
2003; Meinke et al. 2006). In particular, it is now rec-
ognized that user participation in defining the research
agenda and in developing and testing decision support
tools will ensure that the latter have a higher degree of
salience, credibility, legitimacy, and consequently a greater
chance of impacting real-life decisions (Cash et al. 2006).

The salience, credibility, and legitimacy of seasonal
climate forecasts, however, are not simply functions of
technical content, forecasting skill, and methodological rigor. Rather, salience, credibility, and legitimacy are functions of the structure and quality of the knowledge network that connects research scientists and farmers, the articulation of the development of technical content, and its applications in social contexts. Such articulation requires the consideration of technical and normative aspects of both farmers and scientists. For example, although it is important that the parameters and timing of forecasts fit the needs and rhythm of farmers’ decision processes, perceived relevance (salience) is also defined by farmers’ livelihood goals. Keeping land in the family, preserving their lifestyle, and nurturing social networks and economic linkages are among farmers’ foremost goals. These goals are a fundamental part of farmers’ decision-making logic, even as they struggle to “make a crop” each season. The multigenerational and multidimensional perspective means that farmers’ time horizon for coping with climate uncertainty exceeds the seasonal framework of climate predictions. Risk management is framed as a multiyear process, during which farmers accept that both gains and losses will occur but aim to ensure the stability of the enterprise over the long run. Furthermore, even as farmers strive to minimize their vulnerability to climate shocks and financial shortfalls, their experience has led them to perceive uncertainty as inherent to agricultural livelihoods, stemming not only from climate variability but also from the economic, ecological, and institutional milieu. The perceived relevance (salience) of seasonal climate forecasts is thus determined by the importance of climate uncertainty vis-à-vis other decision drivers. Because of this, assessment efforts must take into account the multivariate nature of farming decision to determine whether and how climate-based decision support systems serve the different goals that animate farmers’ risk-management strategies (Moser 2009).

As with salience, credibility (perceived reliability or accuracy) is not merely an issue of statistical significance or technical soundness, nor is legitimacy (perceived objectivity or authority) conferred by scientific reputation. Instead, both are grounded in farmers’ and scientists’ collaborative practices of knowledge production and management. A responsive research agenda that addresses farmers’ information needs and fits their risk-management style will help build credibility and legitimacy by demonstrating a commitment to serving farmers’ interests. For instance, showing “that you understand what it means to be a farmer” will go a long way in convincing farmers that the information offered is produced with their needs in mind. This can be accomplished by presenting information in ways that are easily accessed and understood, not overtaxing on farmers’ time, skills, and mental energy, and in language that is meaningful to farmers. Adding scientists’ contact information and biographic profiles can also help them to “see the people behind the forecast,” fostering “parasocial” relationships that promote confidence and proactive behavior (Sherman-Morris 2005). Credibility and legitimacy can also be built by showcasing personal accounts of how other farmers have used climate forecasts and with what results or sharing editorials by familiar and trusted extension professionals with management advice. Given the reservations that some farmers have toward urban-based and commercial media, the perceived legitimacy of seasonal climate forecasts will be also enhanced by emphasizing the public service nature of the information provider, such as the linkage that the SECC has with land-grant universities, which some farmers have attended, often send their children to, and generally trust in vetting new technologies for them. Finally, making the past performance of seasonal climate forecasts available in terms that make sense to farmers will not only allow them to formulate their own assessments and learn from experience but also signify a commitment to accountability and thereby boost credibility and legitimacy. New theoretical perspectives of technical and scientific knowledge stress its dynamic and systemic nature, defining it as networks linking people, tools, practices, and meanings, rather than as products to be delivered or solutions to be promoted (Clark and Murdoch 1997; Murdoch 1998; Callon 1999; Latour 2005; Moore 2008). In addition to recognizing the social institutions and normative meanings that infuse agricultural decision making and the social nature of information processing, this perspective fits with a view of farming as performance, emphasizing the centrality of social learning and adaptive management.

Seasonal climate forecasts will contribute to reducing risk if such information is integrated in ways that enhance flexibility and resilience rather than create new uncertainties and dependencies. The iterative adjustments and improvisational responses that constitute a great deal of farmers’ operative style are essential elements in this effort, as emphasized by agricultural anthropologist Glenn Stone: “Therefore we must not think of farmers simply acquiring information on a seed or other technology but of farmers developing the ability to perform with a technology under variable conditions; this will serve as a definition of agricultural skillling” (Stone 2007).

In terms of seasonal climate forecasts, the notion of “agricultural skillling” refers to farmers’ ability to creatively employ this new information stream within the context of their existing (and ever changing) circumstances, experiences, competences, practices, challenges, and goals. Although agricultural skillling is largely a place-based
process that unfolds according to the opportunities and capabilities afforded by localities and ecologies, scientific knowledge and institutions have important roles to play. By pursuing collaborations with farmers and other stakeholders as invited partners in the development of climate-based decision support systems, much progress has been made toward ensuring the salience, credibility, and legitimacy of research outcomes. However, an important next step in this direction is acknowledging that information and technologies generated will be adapted as part of the ongoing process of farmers’ agricultural skillings. Acknowledging farmers’ agency in agricultural performance requires that the research community changes its expectations about the extent to which scientists control, or even anticipate, the ways the outcomes of scientific practice are translated into real-life decisions. Such a shift would move the climate research and applications enterprise a long way toward a focus on building farmers’ capacities to perform skillfully in volatile conditions by amplifying the diversity and flexibility of options available to farmers, rather than fostering a sense of security and control centered on the technical quality of climate forecasts and modeled prescriptions.

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REFERENCES


Crane, T., C. Roncoli, J. Paz, N. E. Breuer, K. Broad, K. T. Ingram, and G. Hoogenboom, 2008: Seasonal climate forecasts and


Ingram, K. T., M. C. Roncoli, and P. H. Kirshen, 2002: Opportunities and constraints for farmers of West Africa to use seasonal precipitation forecasts with Burkina Faso as a case study. *Agric. Syst.*, 74, 331–349.


The author affiliations shown in Crane et al. (2010) were incorrect. The correct affiliations of the authors are given below. The staff of Weather, Climate, and Society regrets any inconvenience this may have caused.

REFERENCE