SEASONAL CLIMATE FORECASTS AND RISK MANAGEMENT AMONG GEORGIA FARMERS

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ABSTRACT

Recent increases in the scientific robustness of seasonal climate forecasts have not led to substantial changes in farmers' risk management strategies of actors, largely because there is poor integration of scientific forecasting into farmers' decision-making processes. The goal of the research presented here is to explore the potentials and constraints for farmers' application of seasonal climate forecasts through an analysis of the cultural contexts of their decision-making and information use. Semi-structured interviews were conducted with 38 farmers in southern Georgia, examining their approaches, risk-management, to livelihood goals and strategies, and interactions with weather and climate information. Findings indicate that farmers' management of risks associated with climate variability is embedded within a broad array of social factors, including subjective construction of social and personal identities, goals, and values. These cultural contexts affect the ways that farmers interpret and might apply seasonal climate forecasts to agricultural decisions. These findings indicate that, rather than simply acting as a technical information input, seasonal climate forecasts and forecasters must gradually work their way into farmers' trusted social networks before their potential as risk management tools will be realized. Furthermore, while seeking to produce scientific information to support farmers' adaptive practices, scientists themselves must adapt their own practices to better fit a co-production of knowledge approach.

KEYWORDS: Agricultural decision making, climate forecasts, climate variability, knowledge systems, risk management, southeast USA

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INTRODUCTION

Over the past two decades, a paradigm shift had occurred in agricultural research relative to the nature and role of knowledge in adaptive management. In the conventional research and development model, knowledge is considered to be a technical input, devoid of cultural values, social connections, and power dynamics. New approaches, however, are emerging that conceive of knowledge systems as networks that link people, technologies, practices, and meanings (Callon, 1999; Clark and Murdoch, 1997; Latour, 2005; Moore, 2008; Murdoch, 1998). This conceptualization has profound implications on processes of knowledge generation and communication. The traditional technology transfer model, wherein technologies are developed by specialists working independently at research stations and subsequently delivered to farmers by extension services, is being replaced by 'social learning' and 'co-production' approaches (Leeuwis and Pyburn, 2002). These approaches emphasize adaptation of new technology to meet a user's unique needs rather than adoption of an off-the-shelf technology. Moreover, they incorporate different knowledge held by multiple stakeholders, both experts and non-experts. In agriculture, these ideas have been translated into innovations such as Farmer Field Schools (Moore, 2008; Tripp, Wijeratne, and Piyadasa, 2005) and other forms of participatory technology development (Almekinders and Elings, 2001; Pretty, 1995; Sperling et al., 2001).

The acceptance of collaborative learning and participatory approaches has been much slower in the climate science community, which has emphasized 'appropriation' (Agrawala and Broad 2002) or 'loading dock' models of knowledge production and transfer (Cash, Borck, and Patt 2006). These models assume that the output of scientific research needs simply to be made available to potential users who will then recognize the obvious utility of that information or technology and apply it unaltered to their own circumstances. Given that climate scientists tend to have a relatively distant relationship with the users of the knowledge they produce, they are rarely challenged and enlightened by the hard lessons learned from technology transfer failures. Nonetheless, because public funding for research requires evidence that science benefits society, a greater openness and commitment to stakeholder-centered, demand-driven approaches has also emerged among atmospheric scientists during the last decade (Agrawala, Broad, and Guston, 2001; Demuth et al., 2007; Morss et al., 2005).

The demand for public benefits of atmospheric sciences has led to needs for collaboration among climate, agricultural, economic, and social scientists. For example, seasonal climate forecasting has been integrated with crop simulation modeling and economic analyses to produce information and tools for managing agricultural risks associated with climate variability (Hammer et al., 2001; Hansen, 2002; Hansen et al., 2006; Jones et al., 2000; Meinke and Stone, 2005). While significant advances have been made toward improving the skill and robustness of predictive models, the verification their potential value as technologies for public consumption and application is still unfolding. A decade of experience in different parts of the world has shown that the successful translation of scientifically-produced climate information into a tool for planning and decision making is contingent on how such information integrates with users' existing systems of knowledge and practice (Hartmann et al., 2002; Hu et al., 2006; Jennings, 2002; Lemos et al., 2002; Meinke et al., 2006; Roncoli, Ingram, and Kirshen, 2002; Roncoli et al., 2003; Vogel and O'Brien, 2006).

The research presented in this paper was conducted within the auspices of the Southeast Climate Consortium (SECC), a multidisciplinary applied research project dedicated to developing climate-based risk management tools for crop, livestock, forestry, and water resource management in Georgia, Florida, Alabama, and North Carolina. These tools integrate climate forecasts that are formulated on the basis of correlations between sea surface temperatures (SST) in the equatorial Pacific Ocean and seasonal climate variability in the southeast USA, the phenomenon known as the El Niño-Southern Oscillation (ENSO) (Goddard and Dilley, 2005; Goddard et al., 2001; Piechota and Thomas, 1996). For example, El Niño (characterized by above average Pacific SSTs) typically brings more rainfall and cooler temperatures to the southeastern USA in the fall and winter months, while La Niña phase (characterized by below average pacific SSTs) brings warmer and much drier conditions to the region during fall, winter, and spring. The SECC's main outreach mechanism is an interactive website (*Agro*Climate.org), which provides access to decision support tools based on county-level historical climatic and agricultural data (Fraisse et al., 2006). In addition, the SECC issues climate and agricultural outlooks, which are disseminated via the website and agricultural extension agents. By involving key boundary organizations such as agricultural extension and producer groups, and by incorporating stakeholder feedback on programmatic agendas and tool development, the SECC has explicitly involved end-users in the research and development process (Breuer et al., 2008; Cabrera, Breuer, and Hildebrand, 2006; Jagtap et al., 2002; Roncoli et al., 2006).

In support of the SECC mission, this research explores how farmers in southern Georgia understand and how they might use climate information, specifically seasonal climate forecasts, to reduce uncertainty and enhance resilience to climate risk. The study is an ethnographic investigation of the diverse array of variables that constitute the socio-cultural and agricultural milieu of farmers' decision-making. Its basic premise is that we need to understand vulnerability and adaptation as social constructs with systemic dimensions, rather than as linear functions of environment and technology (Adger, Arnell, and Tompkins, 2005; Füssel, 2007; Nelson, Adger, and Brown, 2007; Ribot, Magalhães, and Panagides, 1996). It is therefore essential to consider the potential role of climate predictions within the context of the intertwining beliefs, motives, habits, options, constraints, practices, and skills that shape farmers' decision making environment. These factors affect trust in communication channels, relevance of information, how information is interpreted and evaluated, how farmer identify and enact response strategies, and how the outcomes of informed decisions are assessed. The analysis of these processes of risk communication and management yield insights into the ways users perceive the salience, credibility, and legitimacy, of predictive information and, therefore, how such information should be translated, packaged, and delivered to them to facilitate its integration into decisions (Cash et al., 2006).

The discussion of research findings relies extensively on transcriptions of farmers' responses, based on an understanding of narrative style as instrumental to conveying the richness and vibrancy of lived experience (Sharman, 2007). The goal is to emphasize farmers' voices and views in reference to how climate risk, livelihood vulnerability, and management decisions interact with their collective memories and personal aspirations. After describing the research methods and the characteristics of the sample, the paper has four sections. These sections elaborate four integrally interrelated themes: how farmers perceive their roles and the values that animate their daily work; how farmers strive to hold onto their land and lifestyle by minimizing risk and pursuing opportunities, how farmers interact with an established information environment relative to weather and climate, and how farmers envision and, in a few cases, experimented with, using seasonal climate forecasts to guide production decisions.

METHODS

The findings presented here are based on 31 semi-structured interviews with 38 farmers, conducted between December 2006 and March 2007, building on preliminary interviews with 8 farmers in January and February 2006. The fieldwork covered 21 counties (Figure 1), which represent the diversity of agro-ecological regions and production systems across southern Georgia. The research focused on southern Georgia because the area its climate is strongly affected by ENSO phases and therefore it is in a position to more directly benefit from the SECC predictive information system. This is also where the SECC has targeted much of its outreach effort to extension agents and agricultural producers.

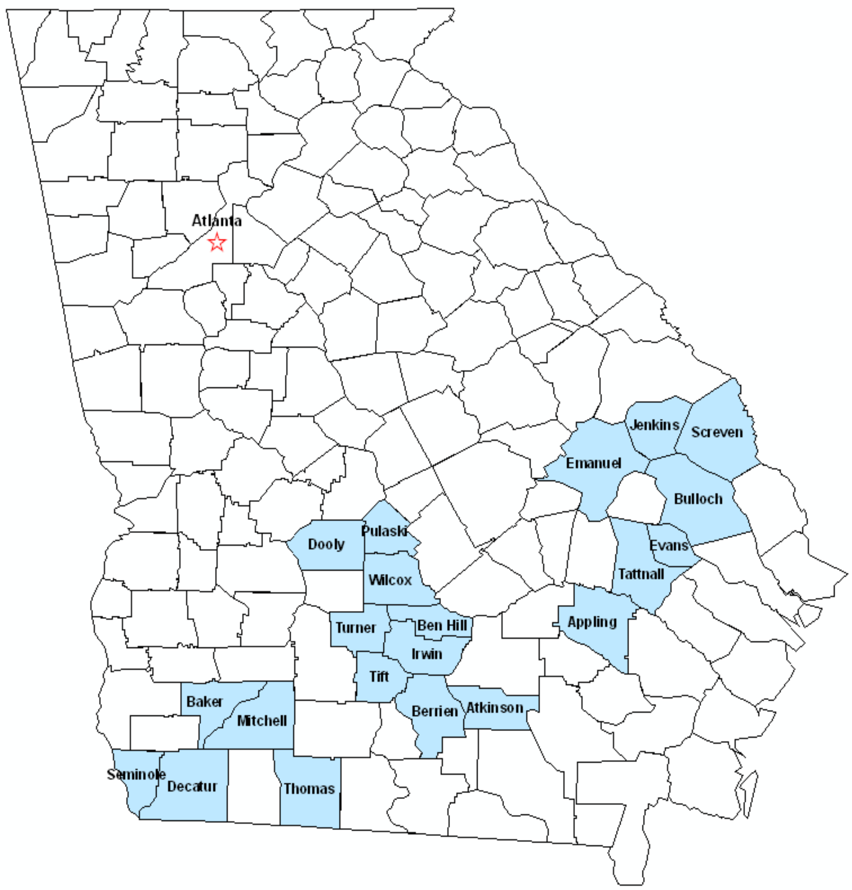

Figure 1. Map of Georgia with shaded counties being those in which research was conducted.

To gain insights into the complexities of farmers' management decisions, the research design used a non-random 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 county agricultural extension agents, who play a key role in facilitating communication between SECC scientists and potential users of SECC tools. Because the extension agents approached growers with whom they were familiar and who they believed would be insightful respondents, this approach skewed the sample toward more successful and better off farmers and those interested in new information and technologies. Not all farmers contacted by agents agreed to participate: some declined because of lack of time or interest in climate forecasts, which was particularly true for farmers with very large operations, who tend to be more protective of their time and less dependent on agricultural extension services and land-grant university research because they might employ private consultants.

The interview protocol was designed to elicit information on farmers' production systems, key climate-sensitive management decisions, and use of weather and climate information systems. Particular attention was paid to farmers' existing strategies to minimize their vulnerability to climate risk as well as the potential application of seasonal climate forecasts and other information produced by the SECC. Upon securing the respondents' permission, interviews were audio-recorded and transcribed to facilitate analysis. Using qualitative text analysis software (NVIVO), the transcripts were coded for various themes that arose during the interviews, including operation profile, perceptions of climate variability, risk-management strategies, and potential applications of climate forecasts. Because of the open-ended nature of the interviews, respondents did not always answer all the questions or elaborate on the same issues, hence the sample size differs among themes.

Most interviews were conducted in extension offices, with a few being conducted in farmer's fields or local diners. When time allowed and computers and online connection were available, respondents were given a brief hands-on demonstration of *Agro*Climate tools and asked to provide feedback on the usefulness of the information and user-friendliness of the website. Occasionally, the extension agent participated in the interviews, facilitating the interaction between researchers and farmers, as they routinely do in their work. While this may cause concern about potentially biased responses, in most cases it was helpful, especially as extension agents are familiar and trusted actors in the local scene. Many of them come from farming families, often living nearby. Others had actually wished to be farmers themselves, but decided to take up employment with agricultural extension for the sake of a stable income. In addition to the intermediary role played by extension agents, rapport with farmers was facilitated by the researchers' association with a land-grant university, particularly the University of Georgia, which some of the farmers or their children had attended.

SAMPLE CHARACTERISTICS

Most respondents were middle age men, as are most farm operators in southern Georgia, so masculine pronouns are used to refer to interview respondents. Exceptions include women who have inherited land but are not actively engaged in agriculture and female women farmers in the rapidly expanding organic agriculture sector. The one female respondent in this research was among the latter, a retired mid-level manager who had established an organic produce farm on family land as a second career. The sample included a few farmers in their 20s or early 30s: most of them were from farming backgrounds and had decided to take up farming after getting a 2- or 4-year degree at a state university. For the rest of the respondents, educational levels ranged from high-school to college graduates, the latter usually in agricultural sciences.

Respondents represent a broad spectrum of production systems found in southern Georgia (Table 1). Operations varied from single-sector enterprises to combinations of several production systems. An average operation integrated two production systems, while the maximum number of systems managed by the same farmer was five. For row crops, the portion of irrigated land managed by an individual farmer ranged from 0 to 75%, while fruit and vegetable operations were entirely irrigated. One farmer explained that one needs to have at least

50% of landholdings under irrigation to make a profit or even to secure a loan from the bank. Availability of water for irrigation varied among the counties visited. Farmers must apply and pay for permits to dig new wells, but not for the water itself. Furthermore, expansion of irrigation is limited by costs of fuel, equipment, and infrastructure.

Table 1: Production Systems

Production System	**Frequency**
Row crops	31
Produce	11
Cattle	8
Pine plantation	7
Hay	4
Pecans	3
Sows	2
Turf grass	1
Goats	1
Poultry	1

Respondents came from families who had been farming in the area from two to at least five generations, with an average of 3.4 generations. As is typical for the area, respondents farmed a combination of owned and rented fields, with farm sizes (including both owned and rented land) ranging from about 100 acres (organic produce farmer) to 8,000 acres (mixed systems). Most (87%) respondents described themselves as full-time farmers, while a minority had part-time jobs, such as selling insurance, agricultural equipment, or agricultural inputs. A few owned shares in ancillary agricultural businesses, such as ginneries, warehouses, or wholesale companies. Two respondents had been farmers, but left full-time farming for jobs in the farm economy, one as a crop consultant, the other as an input salesman.

As in most of the world, farming in Georgia is not an individual undertaking, but a household or extended family enterprise. Most (54%) of respondents owned or operated their farms together with brothers, sons, fathers, grandfathers, uncles, and nephews. In some cases, different family members had their own land and farm, and shared equipment and labor, while in others everything was jointly owned and income was equally divided. Typically, in multi-household arrangements, each individual specialized in a different area, such as managing the crops, supervising labor, running and maintaining equipment, marketing and finance, or computer technology, but key decisions were made in common. It is also common for farmland rental agreements to be forged within kinship networks.

As noted in other studies of family farming (Barlett, 1993, Hu et al., 2006, Breuer et al., 2008), most full-time farmers have spouses who work outside the farm in clerical or professional positions or running a small business. The spouses' health insurance and extra income contribute to the farm enterprise, by reducing costs and smoothing out fluctuations in earnings associated with the farm economy. In the words of a farmer in Wilcox County, "My wife makes a living. She says I have a hobby and she makes a living. She works at the bank, down in town."

Generally more computer literate than farmers themselves, wives often keep accounts and inventories and do bank and insurance paperwork. In some cases, adolescent or adult children also help with computer work associated with the farming operation.

Despite the diversity of agro-ecological conditions and production systems, respondents embraced a similar set of attitudes and aspirations, which informed their discussion of risk management. This value system defines farmers as a community even though, as is the case with all communities, they are internally differentiated in terms of heterogeneities of resource base and adaptive capacity.

RESULTS

Livelihood goals and cultural values

Rural sociology research has clearly established that farmers' values play an important role in their approach to agricultural decision-making (Burton, 2004; Dessein and Nevens, 2007; Neumann et al., 2007). To understand how farmers might use climate information in management decisions, it is important to consider what they value and what they strive for. While farmers often talked about their basic goal to be 'making a crop' by producing enough to cover their costs, farmers operate in a decision environment that is shaped by social values and cultural meanings as well as by economic and environmental forces. Germane comments include:

> I think most people just want to earn a fair and honest living, that's their main goal.
>
> Everybody wants to build equity in their property, pay for the farm and live on that farm.
>
> To raise a family in the country, that's a big part of it. I got nothing against big cities, but I won't live there.

Farmer even rationalized their crop choice in terms of a preference for a relaxed and independent lifestyle as explained by a Decatur County farmer:

> But I don't like to grow cotton. Its 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.

These socio-cultural factors are deeply intertwined the ways farmers perceive themselves in relation to the social networks in which their operations are embedded. While farmers discussed farming as a business, requiring them to be profitable, making money was rationalized in terms of being able to remain on the land and being a good provider for their family, an honorable member of the community, and a patriotic American. According to one extension agent, socio-cultural values are more salient motivators than industrial-scale economic success: "Most people like the way of life here, like being here. Their goal is to raise their families here and be productive with their farms. There are some farmers with the goal of being the mega-, biggest farmer, but not many." Most farmers interviewed had attained a middle class lifestyle: they were sending children to state colleges, took the family on holidays, and bought cars and computers for their wives and children. In addition to making a living, profit is sought to repay bank loans and therefore avoid foreclosure. It has been well documented since the farm crisis of the 1980's 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). The effects can be devastating, involving shame and guilt, and may lead to depression, divorce, and suicide (Belyea and Lobao, 1990; Bultena, Lasley, and Geller, 1986; Hoyt, O'Donnell, and Mack, 1995; O'Brien, Hassinger, and Dershem, 1994).

'Keeping land in the family' was a recurring theme in these farmers' accounts of how they made decisions and managed risk. This goal links past, present, and future generations. It expresses respect for forebears who previously tended the land and demands that current owners manage it wisely in order to be able to transmit it to their children, who are to continue the family legacy and identity as farmers. This ideal of inter-generational continuity, however, clashes against the challenges that currently confront family farmers in the USA. Retaining ownership of a family farm is increasingly difficult in an environment of rising costs, fluctuating prices, and recurrent droughts. A farmer lamented, "Sad part about it is that we've been doing that (holding onto the farm) for four generations. Think about it. I watched it kill my grandfather, my great grandfather, my dad." A college-educated young man from southwestern Georgia declared, "People look at me like I'm an idiot when I say I'm going back to the farm." While farmers wish they could pass on the farm to their children, because of the hardships and uncertainties associated with making a living as a farmer, they encourage their children to complete their college education and pursue stable employment. Typical comments were:

> My youngest one would like to farm but I don't really see a future in it.
>
> None of us want our sons to farm, and I don't know where he'd find a wife that would put up with him farming!
>
> I wouldn't curse them to the occupation!

Yet, it was with pride that some farmers reported that their 'hard-headed' sons were committed to, or at least considering, staying in agriculture, in some cases against their advice.

> I've tried running my son off, to go to town and get a job doing something, but he just won't go.
>
> I've been trying to talk him out of it. But if he's like me and got it in him, everybody in Georgia couldn't talk him out of it. He actually has that in the back of his mind. It's a battle to farm. You got to love it, or don't mess with it. If he does and that's what he decided to do, sure, I'll help him, to be honest with you. If he was standing right here, I probably wouldn't tell you that, but I haven't really encouraged him to be a farmer.

This process of dissuasion was framed as a rite of passage, whereby a farmer decides to either abandon or embrace agriculture as a livelihood and a lifestyle. Sometimes the farmers themselves had been discouraged from engaging in full-time agriculture by their parents or grandparents. "My granddaddy tried to talk me out of it because of the changes he had seen. But it is what I had always wanted to do since I was a small child. As for my kids, I hope they find something else to do." Farmers stressed the autonomy and flexibility of working for oneself, the pleasure of spending time outdoors, and the ability to take time off for hunting and fishing when the farming season is over. Often these accounts culminated in references to farming being something that 'gets in your blood' and cannot be left behind. Furthermore, farmers emphasized the close connection between rural life, family values, and personal 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. We've been through some times when it didn't look like we'd make a living, especially when they cut our tobacco payments.

The central role of moral values and social networks extends beyond the boundaries of community and locality to incorporate linkages with employees, service providers, suppliers, buyers, and the general public. Maintaining good relations with these groups is important to farmers' economic success, and social distribution of risk management. Several farmers rely on family and neighbors for help on the farm, renting land, sharing equipment, and accessing information:

> Being able to rent a farm that's got irrigation is cheaper than me owning irrigation. But I was fortunate to get that farm; that I could rent it. You don't get that opportunity every day, and you don't find many people who will put irrigation on their farm to rent it to somebody else.

An extension commented that, "The risk [in renting] is just so high, and you've got to really trust the people who are taking care of your property for them to rent out that system. . . . It can get extremely expensive in a hurry, so this guy does a pretty good job, he's been a good neighbor or I don't think he'd have what he gets."

Farmers also invoked moral arguments and social commitments to portray themselves as responsible actors in the agricultural economy and in American society. Farmers perceive their work as instrumental to keeping the country supplied with cheap and safe food and often lamented the US government failed to support them in this commitment. The following quotes from a farmer and an agent in Mitchell County, express this understanding of farming in the broader context of food security and social stability:

> You hit the nail on the head right there. The economics of agriculture in this country now are so bad, it's a shame that this country doesn't realize that we're supplying the food and we're doing it with a ragtag army. We don't have the money to properly go about what we're doing: we're cutting corners. We can't hire good help. We have to take who we can get off the street. I'm not trying to make any salt out of it, but it's critical…

> Karl Marx said, back when he was the guy in Russia, 'You cannot have a successful revolution unless the populous is hungry.' Well, America better watch its step. You remember when gas got short after 9-11, just wait until it happens with food. There'll be shoot outs at the [supermarket]. Seriously.

This consciousness of the key role of agriculture in the national economy and security is often coupled in farmers' responses with references to the high-cost, high-risk environment in which they perform such role:

> On a smaller scale for all your gas and nitrate, in 1992, when I started farming cotton, it (nitrate fertilizer) was under $200 a ton, it's over $600 now. We've had to cut back on that, cutting inputs hoping we can make as good a crop. It's not a good situation. It's like

> sending a soldier to war with a pocket full of bullets instead of a truckload. You gotta make every shot count and we're not all sharpshooters.

In particular, the risks associated with uncertainties in climate, markets, and policies are magnified by the high capital investments that are required to make a farm operation viable. One extension agent amplified, "We have a lot of growers who have one-half million or 4 million [dollars] out, the profit margin is very small. It takes a good person to take that money all year and only have 20-30 thousand at the end of the year. But it's not hard to spend that too."

Risk management styles and strategies

Farmers are aware that the climatic, economic, and institutional uncertainties they cope with daily make farming an inherently risky business, often expressed in terms of gambling analogies: "Every time you plant a crop you take a gamble." "That's the way I look at it. You just have to chance it. Do the best you can and hope for the best." Risk, especially risk associated with the vagaries of climate and weather variability, is integral to farmers' concept of farming and they seemed willing to accept that they could not manage their operations in ways that entirely eliminate risk. Reliance on God and a positive attitude were often mentioned as essential in coping with one's inability to control all factors.

> Farmers are the most optimistic people in the world. You have to be. Right now we're sitting here, we had the worst year crop wise ever [2006], and what are we doing? We're getting ready to plant!

> In my operation, I just have to be optimistic and take a chance, and I've always done that, and I think most farmers do. You've got to be optimistic to be a farmer.

The acceptance that risk and occasional losses are unavoidable constitutes a cornerstone of farmers' attitudes toward risk management. This is not to say that farmers think that there is nothing to be done, but they recognize that there is only so much they can control and that risk cannot be entirely eliminated. The farmers acknowledged that occasional failures are inevitable, and sometimes even attempted to quantify the probability: "With dryland corn, probably you are going to make it in 7 out of 10 years." "I always figure with a normal weather pattern, I don't look into abnormal, I always do my predictions [anticipating] a normal weather pattern." By following strategies that have good chances of ensuring some yield during most years and under most conditions, farmers believe that consistency eventually pays off and in the long run, they are safer than if they try to adjust cropping patterns seasonally to maximize short-term gain and.

> 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 know specifically when events will happen, you're faith in God has to be the overruling factor in all of it. And you know it's all gonna work. If you do you're job and the rest of it will take care itself. That's how I look at it. 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.

Nonetheless, farmers endeavor to minimize their vulnerability to fluctuations in production and marketing conditions. As in many parts of the world, diversification over different landholdings and cropping systems is a key risk management strategy (Netting, 1993). Several of the farmers interviewed operated fields in different parts of the county or even in two or three different counties, capitalizing on local-level variability in rainfall, soil types, and other micro-climate features. However, in so doing, farmers avoid spreading their fields too far apart and having to waste time and money shuttling among fields. A farmer from Tift County explains how they would react to a prediction for greater than average rainfall by planting in well drained soils:

> … We'd just have to relocate. That's what we keep all this land tied up for. So we can pick and choose where we want to go with our watermelons and snap beans.

Crop diversification is another key management strategy, whereby farmers spread risks over different operations, as described by one farmer:

> Because it's an average thing. 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. You have to do it all, kind of, in a way, to keep with what we're doing. Some people might do a different thing, but it works for us. That's how we look at it, just 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.

In the last two decades, however, production systems in southern Georgia have become less diversified and, therefore, more vulnerable to environmental or economic perturbations. Increasing specialization has been determined by several shifts in the agricultural economy, including the consolidation of holdings, the expansion of irrigation, increasing reliance on bank loans and government programs, and growing cost of farm equipment.

> So I try to do a better job at row cropping, but we are not as diversified as we were growing up; a lot of farmers back then had a few hogs, a few cows, row crop some, but the equipment now is so expensive and we are more specialized than we were before. We've gotten bigger, but we are doing less things.

Whatever the level of diversification allowed by each farmer's circumstance, a range of agronomic, economic, and institutional variables shape farmers' risk exposure and management strategies. These variables are weighed in terms of their relative certainty and their impacts on profitability, with commodity prices being the primary driving factor. Among row crops, prices for cotton and peanut have stagnated, whereas the recent ethanol-driven boom in maize prices created incentives for farmers to plant more maize, often replacing peanut. One farmer illustrates this complex array of factors that contribute to such decisions as he discussed the recent increase in corn prices:

> Well, we don't know where we're going to fit in with corn yet. That 300 acres of cotton, part of that may be corn. It'll probably be more like 200 acres cotton and 100 acres corn. I don't think we'll replace peanut acres with corn. That's probably contrary to what a lot of farmers around here are doing. Corn is probably going to replace peanuts. But we're in the peanut business, first of all, and our insurance guarantee on cotton is not very good, and its real good on corn and peanuts, so from that standpoint we're leaning toward those two crops, and not as much cotton…. On dry land, we'll have some peanuts, some cotton,

> and some corn. Yeah, we'll plant some dry land corn. We haven't been growing a lot of corn over the last 10 years. Back when we were growing tobacco, we'd only plant corn around the edges of the tobacco fields as a windbreak to protect the tobacco. [Despite] not having been growing much corn over the last 10 years, we've made some really good corn. Our yields are really high, even our dry land yields, so our insurance guarantee is really high, even on dry land, so we may plant some dry land corn. I can afford to take the risk of a drought, because I'll be protected by federal crop insurance. Some of the soil is heavy for us, Tifton-type soil, about as good as it gets around here.

In this case, the price of maize is the starting reference point, but other considerations include insurance guarantees, prevailing soil characteristics, and the requirements of a peanut wholesale operation owned by the farmer, even though peanut is considered less profitable than cotton. Peanut is also sometimes grown as part of a crop rotation system to decrease the risk of pests and disease and improve soil fertility, with little expectation of making a significant profit.

The reasoning by the farmer quoted above highlights the crucial role that irrigation and insurance play in risk management. In addition to crop rotations, availability of irrigated land often determines what crops farmers grow. Among row crops, peanut and corn are almost always irrigated, while cotton, being more drought tolerant, is sometimes grown on dryland. Produce is always grown under irrigation. In addition to supplying crop water needs, farmers use irrigation systems to apply fertilizers, to prevent frost or freeze damage, and to prevent dry, wind-blown sand from covering and killing young plants.

The proportion of irrigated land varies with agro-ecological conditions: in the southwest part of the state, where sandy soils prevail and the water table is closer to the surface, most of the farmland is irrigated, while in south-central and southeast Georgia, farmers have generally less than half of their land irrigated. Recent increases in fuel prices are severely eroding profit margins, as remarked by farmers in southwest and south-central Georgia:

> 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] 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.

> There are so many factors. Just a week or two of age, one rain difference, that's why irrigation is so important. My year was a total disaster. I had excellent corn, but I irrigated it 20 times. People say there is no way to go around 20 times, but it happened this year. I spent a lot of money on fuel, I made the yield, but I spent the profit the make the yield.

On the other hand, dryland farmers must limit their production costs because they are more vulnerable to climate variability than those benefiting from irrigation, as a farmer explained:

> I actually worked for the Department of Agriculture for about 10 years, and when I started farming a lot of my bigger farms I rent, or lease, and I just didn't want to go in debt, the level that it would take to irrigate these farms, so that's why I'm predominantly dry land. And I really have to manage my costs, more than a person who is trying to

> make maximum yield, because they've got irrigation they can spend, spend, spend, and they are going to make a crop, but with me I've got to really be watching the weather and all. I live by the weather.

Finally, crop insurance offers farmers an institutional guarantee for a minimum of return on their crop in the case of natural disasters such as drought, hail, wind, flood, or disease. Availability of different insurance products may influence crop choices, as different insurance products exist for row crops. Some coverage is available for vegetable and fruit (tomato, peppers, blueberry), but is not yet available for other commodities that are potentially profitable but also vulnerable to climate stress (e.g. blackberry, watermelon, and sweet corn).

Weather and climate information environment

Understanding the micro-level social processes by which information is collected, interpreted, and acted upon is essential to allow us to identify how climate forecasts articulate with farmers' decision making processes. This research clearly shows that farmers' interactions with the information environment are mediated by both their social relations and by technologies of information production and delivery.

Farmers are keenly interested in weather information and check it daily, sometimes several times each day, during the growing season. Weather and climate are often discussed with family members and with other farmers at gatherings in local cafés, seed stores, church meetings, extension programs, and within households. The following statement denotes the centrality of weather and climate in farmers' daily life:

> 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[1], 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.

The farmer highlights the importance social processing of weather and climate information. A farmer's wife and children act as conduits of weather and climate information, especially information gathered from online sources. While much literature treats individual farmers as isolated decision-makers, our findings indicate that information processing is a fundamentally social activity, echoing recent findings by other researchers. Among farmers in Florida, Breuer et al. (2008) also found that wives and children facilitate access to weather and climate information through their greater familiarity with computers technology and internet resources. Furthermore, Hu et al. (2006) showed that, when it comes to deciding to apply seasonal climate forecasts to agricultural management decisions, farmers value their wives' opinions more than any other actors, citing the influences of both 'emotional relationship and common ownership of the farm.'

In multi-household operations, different members may specialize in particular management aspects, including the acquisition and integration of information into management

[1] DTN = data transmission network

decisions. Larger operations may also hire crop consultants for specific services, such as soil fertility maintenance, pest management, or marketing. Their roles in acquiring, analyzing, and developing responses to information, makes crop consultants important players in efforts to reduce farmers' vulnerability to climate risk.

Social relations articulate with technology in mediating farmers' access to weather and climate information. Triangulating among multiple communication technologies, and between the latter and their own observations, is standard practice for farmers, as illustrated by the farmer quoted above. Table 2 indicates the frequency of reference to sources of weather and climate information, with television being the most common, followed by the internet. On average, farmers use 3.2 sources for weather and climate information, not including interpersonal exchange of information.

While 50% of the farmers interviewed mentioned using online weather information sources, only 40% of those specified that their wife or children were the ones who actually navigate the computer. The reason that these farmers do not personally look up weather information was sometimes because of poor computer literacy and often because of lack of time and mental energy to search for and process additional information. In small operations having only one or two male adults, farmers must be directly involved in countless details of day-to-day field operations, such as securing inputs, repairing equipment, applying for loans, managing labor, and marketing crops. Familiarity with the internet is more common among younger farmers who grew up when personal computers were more common.

Table 2: Weather and climate information sources

Source	**Frequency**
Weather Channel (TV)	20
Local TV	18
DTN	10
Online (commercial)†	10
Online (unspecified)	9
Print media	7
Online (public)§	6
Cell phones	4
Local Radio	3

† AccuWeather, WeatherBug, Weather.com
§ National Weather Service, National Oceanic and Atmospheric Administration, Georgia Automated Environmental Monitoring Network

Owners of highly capitalized operations may subscribe to private climate services, such as those provided by a data transmission network, which includes updates on weather and commodity prices. Most farmers access data transmission network services at extension offices, seed and feed stores, equipment dealerships, and other farm-related businesses. A few farmers also use subscription-based online weather information services (*Accuweather.com* and *Weatherbug.com*).

Cellular phones are being increasingly used to access real-time weather information to inform hour-to-hour management decisions, such as, the application of pesticides, herbicides, and chemical fertilizers, which are sensitive to wind and rain conditions. Some extension agents also disseminate management recommendations to farmers by text messaging. One crop consultant reported:

> The best thing that's helped me in the last couple years has been cell phones: now you can pull up Doppler radar on the cell phone. It's been bad, because my growers that don't have it are always calling me up, saying 'I'm fixing to make an application and it's clouding up. Is it going to rain, or where is the rain, or how long before it rains?' I say it's time for you to go get yourself a telephone that tells you when it's going to rain.

Farmers interviewed mentioned calling the extension office or nearby agricultural research station for climate information. A few larger farmers also hire consultants to advise them on pest management and other technical issues, and may discuss climate-related issues with them.

In addition to scientific information, farmers, particularly older farmers, also use the Farmer's Almanac and traditional knowledge. The latter notably included the belief that years with 13 lunar cycles tend to be drier than normal. Farmers also reported observing the environment for clues, as do farmers around the world (Huber and Pedersen, 1997; Kanani and Pastakia, 1999; Orlove, Chiang, and Cane, 2000 and 2002; Roncoli, Crane, and Orlove, 2008).

> There is an old saying that in years with 13 moons, there will be a drought. It holds pretty well true, believe it or not. Mr. Wilbur Connor believed in planting by the moon, planting on dark nights, stuff like that.
>
> But talking about the 13 full moons that I can remember: 1980, 1986, 1990 and 93. They were all dry years, but who knows? It shouldn't make a difference, so they say, but it seems to.
>
> Before we had satellites and radars, the old timers would look around and if the lady beetles were breeding in the first week of March, then the threat of frost is over. Do you people use any nature cues to make weather predictions?

While farmers are keenly interested and heavily dependent on short-range weather forecasts, their use of such information is mediated by some skepticism about the information's relevance and accuracy. Even though some farmers acknowledged that weather forecasting has improved tremendously over the last two decades, interviews were characterized by a pervasive discourse about the unreliability of weather forecasts, as illustrated by the responses below:

> I don't put much faith in them cutting hay, I can promise you that. [With a forecast of] 20% chance of rain and it starts pouring outside.
>
> We don't put that much faith in them. We've got a joke around the house, that meteorologist is the only job where you can be wrong every day and still have a job.

Two important criteria in farmers' assessment of the credibility of predictive information are its spatial and temporal scale, as illustrated by the following statements:

> That's a scientific wild guess is what that is, when you go past, in my opinion, a week. They do a good job at 24 hours, they do a fair job at 48... Hey, back here what was it the day before Thanksgiving we were picking cotton; they called for 55 degrees; 'sunny and 55,' and we went to the field—it started snowing at 3:00. They were calling for clear and 55.

> Most of the time, everybody is different. Channel 6 (Tallahassee) says 40% chance of rain for the day and Albany will say 100%. Everybody interprets their information differently. I think Channel 6 for me is more reliable. Of course, I live closer to them, closer to their station, so it works for me.

An important element of this skepticism is farmers' perception of urban bias on the part of single-source, mass-market outlets, such as network and cable television. Because TV weather forecasts are oriented toward the larger audience in urban areas where the TV stations are based, farmers feel these stations do not address their needs. An urban bias represents both an operational issue, in terms of the geographic specificity of information systems, as well as an issue of social relations and identity. Information management is mediated through a sense of place and a sense of self that articulate along a rural-urban divides. In particular, farmers' discourse is infused with a view of rural southern Georgia as a different world than the one inhabited by producers of local media 'up in Atlanta' or the Weather Channel. The use of scientific or foreign terminology in climate reporting exacerbates farmers' feelings 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 (laughs).

The commercial orientation of weather services also conveys the impression that the information they offer is less than trustworthy and does not reflect local realities or farmers' interests:

> I seldom look at the weather if it's on the radio or on the television, it seems to be more of a sale instead of accurate information. In other words, it generally predicts it lower than it gets, generally predicts more rain than you will find, and those things to get people to tune in.

While the SECC produces seasonal climate forecasts and not short-range weather forecasts, farmers do not draw a hard distinction between the two. This means that farmers' attitudes toward weather forecasting directly shape their perception of seasonal climate forecasts. Unlike with short-term weather forecasts, farmers are not in the habit of seeking seasonal climate forecasts. Instead, climate forecasts are passively encountered in the agricultural press, mainstream media outlets, or data transmission network reports. However, even the farmers who acknowledged encountering seasonal climate forecasts said that the information does not significantly affect their management strategies. The quotes below, from three different informants, illustrate farmers' attitudes toward seasonal forecasts.

> Oh, I look at [90-day forecasts], generally when I am going to buy fertilizer, in a place that has the DTN. We have a look at it, but I've never really paid attention to it.

> I really don't have a source for the long-range forecast. I go to meetings two or three times a year and there is usually someone there that has a handout for long-range weather.

> It's 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.'

Farmers' attitudes towards seasonal climate forecasts are also affected by their perceptions of other types of climate forecasts, namely hurricane season activity. Hurricane forecasts are highly salient information for farmers in the southern coastal plains. The salience of hurricane forecasting was magnified by the devastation wrought by the active hurricane seasons of 2004 and 2005, especially the impact of Hurricane Katrina on New Orleans. Inaccurate forecasts for an active hurricane season in 2006 were cited by 18% of farmers as a justification for skepticism toward seasonal climate forecasts.

> … But you know how predictions are. Like this year, there were supposed to be so many hurricanes in our area and it didn't happen. So I just sort of take it as whatever happens is whatever happens. That's just my opinion. We don't have any control. Predictions are predictions.

> They were talking about hurricanes last year, but how many hurricanes did we have year? We didn't have them. The prediction said we were going to have a whole lot of hurricanes that we didn't have. Did you hear that prediction? It sure didn't do what they said last year.

> Last year, the NWS[2] 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.

Farmers characterized the use of inherently uncertain climate forecasts as a risky management strategy. However, despite approaching them with fundamental skepticism, farmers admitted that they are willing to consider using seasonal climate forecasts, but only if they show a good track record over time. Track record was understood largely in terms of correspondence between the forecast and farmers' experiences, not in terms of the quality of the science:

> Over time, if you look at the law of averages, then [a seasonal forecast] could probably be a useful tool. Just starting out, that could be something to look at, to use it and judge it to get some kind of record keeping on it to see how it would work. But like I said, the longer its in use and you can see the reliability and the trends, then that would be something that would be useful.

> If you are predicting a wet spring and it comes up dry, I'm not going to pay near as much attention next time. But if it's accurate, then, you know, 'They're really doing something here. This makes a lot of sense. We gotta look at this.' If they get this to a point that it's a technology you can depend on, then maybe I'll need to be ready plant early or not.

> I would like that. Anything that is qualified information that can help to make a better judgment and decision on the farm level as far as operations, any information you get is

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[2] National Weather Service

> educational. I know it's not a 100% guarantee. If it was, you wouldn't be here asking me questions, you would be saying 'Here, this is what it costs!

Even with improved accuracy and detailed track records, the transformation of seasonal climate forecasts from a hazy notion in the back of farmers' minds to a decision tool for pro-active planning will require greater integration of forecasts into farmers' habitual information streams.

Applying climate forecasts to management decisions

In addition to the unfamiliarity with the information and skepticism for longer-range, broader scale predictions, the applicability of seasonal climate forecast is challenged by several aspects of farmers risk management context and style. In particular, climate patterns and forecasts have a high degree of uncertainty, compared with the degree of knowledge and control farmers have with respect to other decision drivers (Table 3), as expressed by an extension agent:

> [Farmers] have got to look at the most reliable things, so first they start looking at commodity prices, 'Can I make a profit on this commodity this year?' Here, with our deep sand, it's very iffy on making a profit, so we're highly irrigated. The next decision was to look at the weather report and turn on the irrigation system. We irrigate. It's those factors that they can practically control, and weather predictions aren't to a point yet that we can apply them practically.

Another constraint to forecast use is that heavy financial investments in machinery and infrastructure considerably reduce farmers' flexibility to alter production decisions. As one farmer stated, large operations are like 'battle ships' set on a determined course that cannot be turned around at short notice. They must use the equipment they invested in, even if climate or price outlooks indicate that returns may be suboptimal. Furthermore, farmers strive to maintain the market linkages and labor flows that they need each year, even though occasionally this may cost them their profits. This logic is expressed in the following responses to a question about what farmers would do if they received a seasonal climate forecast for drier than average conditions:

> I don't know if I want that responsibility. Really. If I knew this year was going to be a bad year, I'd sit back and not do anything. If you're gonna lose a bunch of money this spring, what are you gonna do with all this help, all this equipment. It'd be a lot easier to not spend the money and sit around, but that doesn't help. If you got somebody that's selling you stuff for you, they've gotta have product because the grocery stores are gonna want them, the chain stores are gonna have to have them.

> About 12 or 13 years ago my brother told me, 'I see where they are predicting record drought this year, and record temperatures, and if I was you I wouldn't plant anything. They are calling for a record bad year.' And I told him, '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.' And it was a great year. It wound up being a great year.

Table 3: Non-climate decision drivers

Non-climate decision drivers
Agronomic considerations (rotation)
Commodity prices
Insurance constraints
Input prices
Credit options
Price support policies
Trade policies
Immigration policies

These and similar comments highlight a disconnection between climate forecasts and farmers' approaches to risk management. The latter allows that one may gain in some years and lose in others, but in the long range the risk is less than if one tried to adjust management decision year-by-year. Furthermore, trying to produce even in poor years is an important part of maintaining functional relationships with laborers and distribution networks, both of which are especially important in the fresh produce sector. As discussed in section on risk management styles and strategies, farmers tend to make decisions based on a perspective and calculations that span a decade or longer rather than on short-term adaptive responses based on expected seasonal conditions.

> [Seasonal climate forecasts] really wouldn't affect me. I plant the corn on the first of March and I plant peanuts the first of May, so forecasts don't affect my planning in any way. I'm going to start the same time every year. If I know it's going to be a cool wet spring, I'm not going to delay or speed up. I'm going to stay on the same schedule. It doesn't shift one way or another. Sometimes they say El Niño is going to do this or that, and it's the complete opposite. So it's just the luck of the draw. You go your regular ways, and if it works, it works, and if it doesn't, you can try again next year. I've seen one where they said we were going to have a dry pattern, and that'll be one of the years when you see 20 inches of rain.

In addition, when deciding what to grow, farmers consider an array of factors, with climate being only one of them, as exemplified by the following quote:

> There is a whole quandary of factors that go into deciding what somebody has to grow. What is their debt service? Can you grow a lower value crop? If I knew it was going to be dry and I didn't have a big debt service, I'd grow a very drought resistant and inexpensive crop, maybe grain sorghum or something. But if I have a high debt service I have to pay off every year then you've got to go for a higher input, higher yielding, and higher value crop and hopefully you can get enough water. So, there are a lot of factors that go into deciding what to do and climate might be one of them.

In this multivariate cognitive process, climate forecasts introduce a new element, one that is still largely untested and unfamiliar. Consequently, farmers are not only hesitant to trust it, but are also sometimes hard pressed to imagine how the information might be useful to them, as stated by a farmer in Wilcox County: "I'm sure it would [affect me]. It's hard to answer questions on things you've never been familiar with." The following exchange by two farmers in Turner County exemplifies this ambivalence:

> F1: I always hear when El Niño is mentioned now and you get around a lot of farmers they say, 'You know it's gonna be an El Niño and I'm not gonna plant this year. We don't need to,' but in a joking way. But people do think about those things now. It's [El Niño] made a lot of believers out of people. It's hard to say what you'd change though. Like [F2] said, if you're gonna plant, you gotta plant. I don't know what you'd change.
>
> F2: I think accuracy is the big thing. It'll play a big part. To be honest with you, when you asked me about a 60- or 90-day forecast, and I do look at that a lot of times, if nothing else it makes me feel good that I'm going to be getting some rain. Whether I can change anything, I don't know. I'll have to think about that. I guess we just do it to satisfy our minds a lot of times. I look at forecasts a lot during the year, I'm sure a lot of people do. There's gotta be ways that, maybe subconsciously, we make decisions and we don't even realize it.

Even if forecast reliability improved, farmers did not recognize the availability of such information as an unqualified advantage. Farmers understand that they are not the only actors in the agricultural sector that may use the information to their own benefit. Lending institutions, crop insurers, commodity brokers, and input suppliers will also be able to access seasonal climate forecasts and use them for their own purposes. In fact, evidence from other parts of the world shows that banks may refuse credit to farmers if poor rains are predicted (Hammer et al., 2001). Likewise, insurance companies may increase rates and commodity buyers may adjust prices based on information about possible fluctuations in crop yields. Given that institutional actors have more resources than individual farmers to seek out, assess and act on information, seasonal climate forecasts have the potential to place farmers at a disadvantage, as was discussed by a farmer and an extension agent:

> F: That's scary. [The banks] might tell me to sit this one out (not farm at all for a season).
>
> EA: I can tell you that if you have accurate data on the weather that's going to be out there, lending institutions and [peanut] shellers are going to use it more than the farmers will. They are lending the money, they are taking a risk also, and it's a time factor. Farmers don't have so much 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 this was available, farmers would not be the only ones using it.
>
> The farmer is not on a level playing field with everyone else. The one thing he still has is the unknown of the weather. I know, just dealing with [lenders, insurers, brokers] on a daily basis, and they're not mean people, they're good friends of mine, but still, I know, by dealing with them on a daily basis, that the weather really plays in to how they think about things.

> F. …As far as forecasting, with blackberry prices, if Wal-Mart had this tool, they could look and say to Sunnyridge, 'We're 90% sure that you're going to get a ton of rain this coming June. We're going to buy 50% of our crops from California instead of ya'll, to be sure that we're gonna have a supply of fruit.'

Despite these limitations and reservations, most farmers recognized that, if proven accurate and if delivered with enough lead time and in suitable format, climate forecasts could have considerable utility. Respondents enumerated a wide range of potentially beneficial forecast applications (Table 4), as it was the case for other studies in the region (Breuer et al., 2008). Changing crops and crop varieties to plant were among the most commonly mentioned forecast uses, followed by modifications in planting time, input purchases and application, and in the size and location of planted areas. Given that most vegetables can be grown and harvested within the 3-month timeframe of a seasonal climate forecast, produce farmers expressed particular interest in developing adaptive plans. Being more vulnerable to drought, dryland operators also responded positively, although not all of them:

> As far as cropping plans on weather forecasts, I don't think it'll enter my thought process and decision making. Some like it. When you have irrigation, you got sweet corn, vegetables, grain corn, wheat double-cropped with cotton you got a lot more options and therefore people in that situation could use your services a lot more than I would.

Table 4: Potential applications of season climate forecasts

Decision with potential to be influenced	**Frequency**
Crop selection	23
Planting timing	16
Input management	14
Land management	13
Variety selection	11
Marketing strategy	8
Harvesting schedule	4
Insurance strategy	3
Herd management	2
Hog lagoon management	1

In addition to their potential for mitigating climate risk, some farmers also recognized that climate forecasts could be used to maximize competitive advantage, as also found by research on climate forecast applications to agriculture in other parts of the world (Phillips et al., 2002; Roncoli et al., 2003; Roncoli et al., in press). The following quotes exemplify such opportunities:

> I have an advantage in that my pump is electric. So in some cases, I might be inclined to plant something that I am going to water where I would have a competitive advantage. That is, if I thought it was going to be a dry year and people who don't have irrigation . . . It might provide me an opportunity.
>
> 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.

While dissemination of the seasonal climate forecasts is too recent for responses to occur in great numbers, we found anecdotal evidence of uses of climate forecasts. In January 2006, the SECC issued a forecast for La Niña, which, in southern Georgia, translates into drier and hotter conditions in the spring and early summer months. This forecast was distributed to agricultural extension agents across Georgia, and subsequently, a county agent included the forecast in his weekly column in the local newspaper, along with the recommendation that farmers without irrigation consider growing drought resistant peanut (variety 02-C) instead of the more common, higher yielding Georgia Green. The agent later reported that many dryland farmers in the county followed his advice, and thus avoided suffering yield losses during the ensuing drought.

Similarly, one farmer reported having used climate predictions in deciding whether to plant cotton or corn. His account illustrates the myriad of factors that farmers consider when acting upon such predictions, including information about climate patterns in other producing areas of the country:

> 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 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. Maybe another 20%, or 40 acres, of dryland. 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 adequate weather, and the price is up there anyway. And the price of cotton is not looking so great.

Overall, despite the concerns and challenges mentioned above, farmers see climate forecasts as potentially useful and they are therefore interested in receiving them, especially as other stakeholders and competitors will have access to them. Although, so far, most farmers have had little exposure to climate forecasts and have only referred to them as 'conversation pieces' or for 'peace of mind,' after some explanation and prompting, they were able to envision many possible applications to risk management.

DISCUSSION AND CONCLUSION

The interviews presented in this paper reveal how farmers of southern Georgia perceive, experience, and manage climate variability as well as the potential applications and constraints for using seasonal climate forecasts to manage risk or enhance opportunities. By seeking to facilitate the integration of farmers' needs and goals into the development of climate information services for agriculture in the southeastern USA, this research constitutes a key stage in a process of co-production of knowledge between scientists and farmers. The participatory approach embraced by the SECC provides an enabling environment for the formation of climate-centered knowledge networks linking university scientists, agricultural extension, and farmers. Three variables have been identified as instrumental to the ability of scientific information to influence risk management practices and policies, namely its perceived salience, legitimacy, and credibility (Cash et al., 2005). These attributes, however, are not simply functions of technical content, methodological rigor, and forecasting skill, but they are socially constructed so that they incorporate cultural meanings, values, and ideals.

While it is important that the parameters and timing of predictive information fit the needs and rhythm of farmers' management processes, salience is also defined by the goals that motivate farmers. Farmers identified keeping land in the family, preserving their lifestyle and reputation, and nurturing social networks and economic linkages are as key goals. These goals are a part of farmers' decision-making logic even as, during each growing season, they struggle to 'make a crop' or 'make money.' This longer-term and multi-dimensional perspective means that farmers manage risk according to a temporal scale that spans beyond the seasonal framework of ENSO-based forecasting and that recognizes that they will experience both gains and losses over time. The central role of diversification, whether of field location or crop selection, as a way of buffering against risk points to another discrepancy between the spatial scale of seasonal climate forecasts and that of production decisions. The flexibility required by crop diversification and adaptive management in response to predictive information is constrained by the substantial infrastructural investments and indebtedness that farmers undertake to stay in business. These constraints increase farmers' vulnerability to environmental and economic fluctuations, threatening the resilience and continuity of family farming.

Even as farmers strive to reduce their vulnerability to climate shocks and financial shortfalls, their experience has led them to perceive risk and loss as inherent to agricultural livelihoods. Uncertainties and pressures stem not only from the climate environment, but also from the economic and institutional environments. In some cases, as yields and support for traditional commodities diminish, farmers are shifting to new high value crops that are disaster.

In this risk environment, climate forecasts offer some potential for reducing uncertainty and enhancing opportunity. As detailed by the farmers interviewed, they can help farmers save time, reduce costs, prevent losses, increase yields, and gain advantages over competitors. But for this promise to be realized, such information needs to be perceived by farmers not only as salient, that is, pertinent and applicable to their own circumstances, but also as credible and legitimate. This trust is not merely a corollary of statistical significance or scientific soundness, but is powerfully shaped by the fabric of cognitive habits, social context, and life experience in which predictive information is introduced. Farmers' attentiveness and openness to seasonal climate forecasts is contingent on whether they can be incorporated into familiar knowledge networks and how they mesh with other salient information that is processed through those networks. Farmers need to be able to encounter and experiment with forecasts regularly, in order to learn how to integrate them into their management decisions with the right balance of confidence and caution.

Because land-grant universities have provided long-term support of the agricultural sector and because farmers have personal connections with them, land-grant universities are well positioned to be active members of such networks. Confidence in a climate information system would, therefore, be enhanced by identifying its outreach mechanisms such as *Agro*Climate, as being clearly linked to the land-grant universities that farmers endorse. Furthermore, credibility and legitimacy must be grounded in farmers' experiential learning styles and social practices of information processing. For example, publicizing the track record of climate forecasts and establishing mechanisms to compare it with farmers' own predictions and observation would enhance farmers' ability to interpret climate forecasts and utilize them appropriately. Ensuring that information is easily accessed and understood, without overtaxing farmers' time, skills, and mental energy, and that it is conveyed in terms that are meaningful to farmers, would denote an appreciation for the challenges and constraints they face, thereby 'showing that you understand of what it means to be a farmer.' Showcasing personal accounts by farmers, editorials by known extension professionals, and scientists' contact information and biographic profiles to help farmers 'see the people behind the forecast' would foster 'parasocial' relationships that support proactive responses (Sherman-Morris, 2005). Finally, a responsive research agenda that addresses farmers' information needs and fits their risk management style will also contribute to building legitimacy and credibility by demonstrating a commitment to serving farmers interests.

Getting beyond the 'loading-dock' approach to climate technology development requires greater communication and understanding between climate researchers and lay-users of information. Implicit in this process is the acknowledgement and incorporation of the socially embedded nature of farmers' risk management decision making. This research shows that seasonal climate forecasts and risk management tools have a potential role in the farmers' decision-making processes. However, understanding farmers' life experience and values is key for recognizing the potential value and limitations of seasonal climate forecasts. Just as climate variability is one risk factor among many, climate information systems will only be one input among many. Ultimately, scientists need to accept that even the information and technologies they generate in collaboration with farmers will be adapted in terms of farmers' own observations, experiences, and knowledge and might be used in ways that are different or of a lesser magnitude than they had anticipated.

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Table 5: Potential applications of seasonal climate forecasts (detailed)

Parameter	Forecast	Timeframe	Response
Rainfall	Below normal	Spring-Summer	Plant drought tolerant varieties (but seed supply is limiting factor)
			Plant more drought tolerant crops (e.g. cotton, soybean, wheat, sorghum)
			If irrigated, plant more water demanding crops to take advantage of the higher prices (and exploit comparative advantage versus dryland farmers)
			Plant more varieties that establish root systems faster (so that they can withstand drought)
			Plant peanut and corn in lower areas that retain moisture
			Delay planting to minimize the risk of drought after planting and plant shorter cycle varieties
			Plant on ridges rather than furrows
			Plant crops with better insurance coverage and government programs to make up for yield reduction
			Leave marginal fields unplanted,
			Do not plant spring crops
			Don’t plant pine trees (esp. long leaf)
			Leave bottom layers of pine needles to retain nutrient/moisture on marginal lands (e.g. sandy)
			Rent out land rather than farming it
			Ensure irrigation equipment is in working order and cash is available for fuel
			Apply more irrigation to avoid falling behind on soil moisture
			Reduce or eliminate nitrogen application
			Stretch out pesticide and fungicide applications because less is needed and to minimize costs
			Defoliate and pick cotton incrementally so that foliage can preserve soil moisture
			Reduce expenditures as much as possible
			Put off equipment purchases (to save money)
			Increase insurance coverage (e.g. from 50% to 75%)
			Cut hay early to offset shortage of livestock feed
			Buy feed early before price rises
			Hold off to contract crops in anticipation of possible yield shortfall or price hike

Parameter	Forecast	Timeframe	Response
Rainfall	Above normal	Spring-Summer	Plant crops (esp. peanut, corn) on upland fields, well drained soils
			Plant dryland fields (freeing up irrigated field for more planting)
			Do not plant peanut in heavy soils
			Do not plant sweet potato or watermelon
			Spray less chemicals which get washed away
			Pay more attention to risk of rust in grain crops (?)
			Adjust contracts to lock in price if a market glut is expected
			Drop insurance coverage for some crops to save money (except for corn)
			Lower levels of hog waste lagoons to prevent overflowing after heavy rains and in anticipation of lower absorbing capacity by rain-soaked soils
		Fall-Winter	Harvest peanut early (August) to avoid exposure to rain during harvest
			Ensure you have enough labor, equipment to harvest quickly (eg. green bean)
Temperature	Below normal	Spring-Summer	Plant corn later to prevent freeze after planting
			Plant cotton later (but early enough to be ready for harvest before hurricane season)
			Ensure enough drying and storage capacity to get produce off the field quickly (cooler spring means later harvest, therefore exposure to rain and cold)
			Plant vegetable (potato, broccoli, peas) in Feb, plant melon in April
			Do not plant a cover crop to avoid soil being too cold to plant in the spring
		Fall-Winter	Plant fall/winter crop early so it establishes before cold sets in
			Transplant onions in October rather than Dec (but must know by Sept)
	Above normal	Spring-Summer	Plant more cotton, less peanut and corn (which are more easily stressed by heat)
			Ensure good ventilation in poultry/hog facilities, hire labor for frequent monitoring of conditions
		Winter	Prepare to buy and apply more pesticides and herbicides after planting
			Buy fungicide for white mold in peanut and tomato wilt earlier (before price goes up)

Parameter	Forecast	Timeframe	Response
Hurricanes	Greater frequency	Fall	Plant storm resistant corn varieties or do not plant a second (Fall) crop of corn
			Plant early maturing varieties of soybean or peanut to harvest before October rains
			Wait to defoliate cotton to protect bolls from damage
			Shake nuts off pecan tree to lighten limbs and prevent damage from heavy winds