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Abstract

To explore Extension professionals' perceptions of the potential impact of climate variability and climate change on agriculture and to identify the top climate-related issues facing farmers, we conducted interviews with agricultural Extension personnel from Alabama, Florida, Georgia, and South Carolina. Of those interviewed, 92% believed climate change will affect agriculture a moderate amount or a great deal. Qualitative analyses revealed that the Extension professionals considered scarcity of water resources, temperature fluctuations, pest and disease pressures, forecast challenges, seasonal variability, and adaptation strategies as among the most important climate-related issues affecting agriculture in the Southeast.

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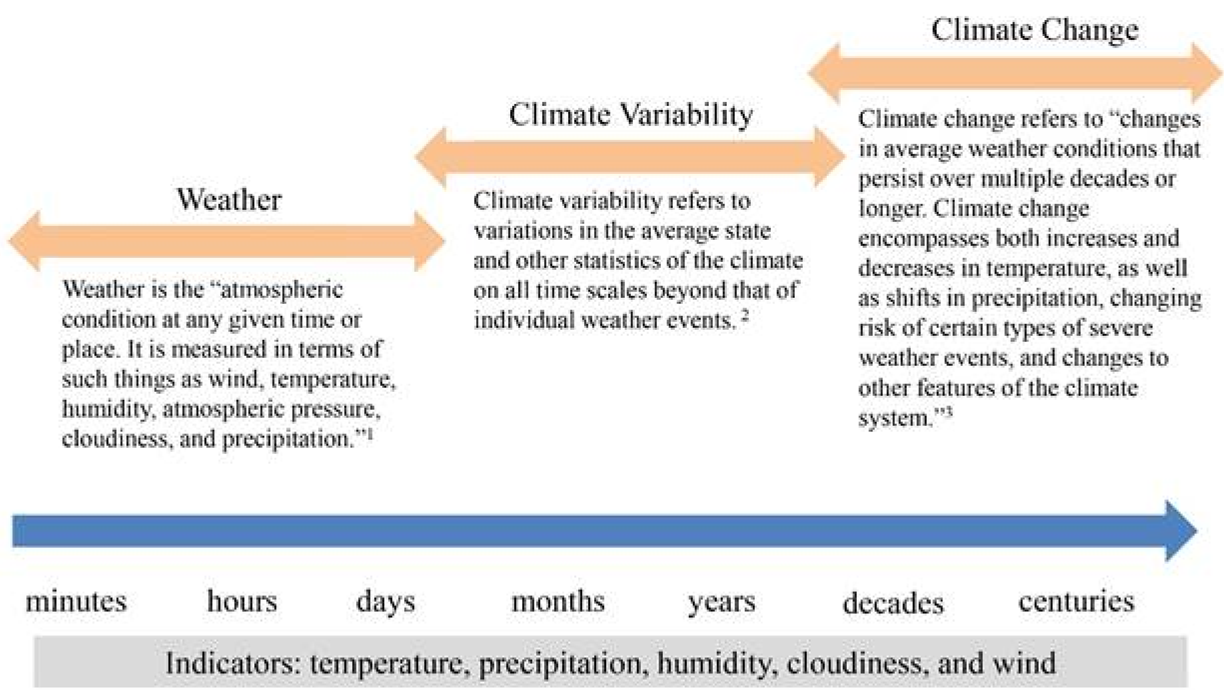
Introduction

Agricultural productivity is vulnerable to weather as well as both short-term climate variability and long-term climate change (see Figure 1). Across this time continuum, fluctuations in conditions such as temperature and precipitation can be either beneficial or detrimental to agricultural production; susceptibility to changing conditions depends on multiple factors, including crop grown, crop varieties, location, soil conditions, and water access (Asseng et al., 2013; Layman, Doll, & Peters, 2013). These variations also directly affect the efficiency of field practices, availability of water supplies, irrigation timing, pest and disease pressures, and severity of soil erosion. In addition, climate extremes—heat waves, storms, droughts, heavy rainfalls, and floods—frequently pose challenges for farmers and may reduce agricultural yields (Anwar, Liu, Macadam, &

Kelly, 2013; Asseng et al., 2013).

Figure 1.

Understanding Weather, Climate Variability, and Climate Change Over Time



Sources: [1]U.S. Environmental Protection Agency, "Weather," 2014; [2]Intergovernmental Panel on Climate Change, 2014, p. 121; [3]U.S. Global Change Research Program, "Climate Change," 2014.

There is a rapidly growing and evolving body of research on the general climate beliefs of farmers and their perspectives on the magnitude of future climate impacts on agriculture (Arbuckle et al., 2013; Gramig, Barnard, & Prokopy, 2013; Liu, Smith, & Safi, 2014; Rejesus, Mutuc-Hensley, Mitchell, Coble, & Knight, 2013). There is also an emerging body of research about the general climate beliefs of Extension professionals (Monroe, Plate, Adams, & Wojcik, 2014; Wojcik, Monroe, Adams, & Plate, 2014), Extension professionals' perceptions of the usefulness of climate forecasting (Breuer, Cabrera, Ingram, Broad, & Hildebrand, 2008; Breuer, Fraisse, & Cabrera, 2010; Cabrera, Breuer, Bellow, & Fraisse, 2006; Fraisse et al., 2006), and the willingness of agricultural advisors to incorporate weather and climate information into their advice to farmers (Haigh et al., 2015). Prokopy and colleagues (2013, 2015) have examined the perspectives of Extension professionals on the existence of climate change, its causes, and its significance for agriculture as well as the relative utility of weather and climate information over different time scales. In their survey of midwestern agricultural advisors, Prokopy et al. (2015) found that all advisors, including Extension personnel, strongly supported the ideas that "farmers should take additional steps to protect farmland from increased weather variability," that advisors "should help farmers to prepare for the impacts of increased weather variability," and that "it is important for farmers to adapt to climate change to ensure the long-term success of U.S. agriculture" (p. 267). These authors also concluded that despite research showing a diminished influence of Extension on farmers over time, Extension remains a trusted source of information for farmers as well as agricultural advisors and that Extension educators need to be better prepared to deliver information related to climate and agriculture (Prokopy et al., 2015). We build on this literature by exploring the specific climate-related issues Extension professionals believe to be the most important issues facing agriculture in the southeastern United States.

Methods

Fifty Extension professionals from four southeastern states (Alabama, Florida, Georgia, and South Carolina) were interviewed about their beliefs, attitudes, and perceptions regarding climate variability and climate change as well as climate-related agricultural issues. The semistructured interview was developed by our team and received approval from the institutional review board at the lead institution. We first identified potential respondents as those whom we knew to participate in climate-related trainings, and we identified additional participants by using snowball sampling. Efforts were made to sample from four major Extension roles (i.e., county faculty/Extension agents, state Extension faculty members, researchers, and administrators). This sampling strategy was designed to include Extension professionals engaged with climate issues related to agriculture, such that they had a knowledge base for responding to relevant questions (see Table 1 for demographics).

Table 1.

Sample Characteristics

Characteristic	**No.**	**%**
Gender		
Male	39	78
Female	11	22
Race/ethnicity		
Caucasian	40	80
African American	5	10
Hispanic	5	10
Education		
Bachelor's degree	2	4
Master's degree	17	34
Doctoral degree	31	62
Extension role		
County faculty/Extension agent	13	26
State Extension faculty	17	34
Researcher	10	20
Administrator/director	10	20
State		

Alabama	11	22	
Florida	18	36	
Georgia	11	22	
South Carolina	10	20	
Provides climate information			
Yes	28	56	
No	22	44	
Target audience for climate information			
Farmers	25	50	
Ranchers	8	16	
Faculty	17	34	
Perception of extent to which climate change affects agriculture			
Not at all	0	0	
A little bit	4	8	
A moderate amount	18	38	
A great deal	26	54	
	M	Min	Max
Age (years)	49	29	69
Extension experience (years)	15	1	37

The 45- to 60-min interviews were conducted via phone, recorded, and transcribed. The full interview included questions on climate-related issues, training issues in Extension, attitudes about climate change, strategies and practices related to adaptation to climate variability and climate change, and suggestions for project implementation. The full interview protocol can be obtained from the first author. For the study described here, respondents were asked "What are the most important climate-related issues that you think are currently affecting agriculture in your state? Please rank these issues in order of priority starting from 1 (highest) to 3 (lowest)." They were then asked to explain why their top issue was important and to provide examples of possible agricultural effects. Respondents also completed a brief online survey addressing their beliefs related to climate and agriculture.

Responses were qualitatively analyzed through the use of an inductive coding frame, in which codes were directly derived from a reading of the text (Thomas, 2006). Two individuals independently coded the responses, and intercoder reliability was established at the level of Kappa = .851, defined as "almost perfect agreement" (Viera & Garrett, 2005, p. 264). Although coding discrepancies occurred infrequently, all were resolved by a three-person team, and full consensus was achieved. Codes were counted and recorded by number of mentions for each level of priority (see Table 2 in the following section).

Results and Discussion

The codes were organized under the major headings of (a) climate-related risks and (b) information and management needs. The most frequently mentioned codes are presented in Table 2 and discussed thereafter.

Table 2.
Numbers of Mentions of Climate-Related Issues in Agriculture, Tallied in Order of Priority (*n* = 50)

Code	No. of mentions as #1 priority issue	No. of mentions as #2 priority issue	No. of mentions as #3 priority issue	Total mentions
Climate-related risks	47	36	29	112
Water scarcity	41	10	7	58
Drought	26.5[a]	0	0	26.5
Rainfall patterns	5.5[a]	5	1	11.5
Irrigation	3	2	3	8
Multiple	4	0	1	5
Competing use	1	1	1	3
Groundwater availability	1	1	1	3
Saltwater intrusion	0	1	0	1
Temperature	1	11	6	18
Pests and diseases	2	9	5	16
Seasonal variability	3	2	5	10
Extreme weather	0	4	2	6
Magnified risk	0	0	2	2
Climate uncertainty	0	0	2	2
Information and management needs	3	11	7	21
Forecasts	1	7	4	12
Weather	0	3	3	6
Seasonal	1	3	0	4

Climate	0	1	1	2
Adaptation	2	4	3	9
Planting dates	1	3	1	5
Crop selection	0	1	2	3
Decision support tools	1	0	0	1

Note. Each individual could generate three mentions based on his or her top three priorities, so the full number of possible mentions is greater than the number of respondents. All 50 respondents provided a #1 priority, 47 provided a #2 priority, and 36 provided a #3 priority, for a total of 133 mentions. [a]One respondent requested ranking both drought and rainfall patterns as the #1 issue, so the coders assigned a ½ code to each of these responses.

Climate-Related Risks

When identifying the top three climate-related issues facing agriculture in the Southeast, respondents included challenges such as water scarcity, temperature, pests and diseases, and seasonal variability.

Water Scarcity (58 mentions)

Water scarcity was the most frequently mentioned climate issue, with specific subcodes being drought, rainfall patterns, irrigation, multiple (i.e., respondent mentioning multiple water scarcity issues), competing use, groundwater availability, and saltwater intrusion.

Drought (26.5 mentions)

When talking about drought, respondents provided the simple logic that water is essential to growing healthy plants and to achieving a strong yield. A state Extension faculty member explained, "Drought affects production, and if you can't produce, you're not going to make money. That's kind of obvious, but it's not trivial."

Other interviewees discussed more specific issues, such as the reduction of crop yields and associated expenses. A state Extension faculty member said that during a drought, "farmers [have] to replant the crop . . . so it's increasing fuel expenses, seed expenses, and labor expenses." Many respondents emphasized that drought was especially damaging for dryland farmers.

In discussing drought, several respondents proposed irrigation as a solution. One county agent said that irrigation makes lack of rainfall "a minor issue." However, some respondents also discussed the limitations of irrigation from the perspective of competing use, with one respondent stating, "Access to water is getting less and less. And it definitely is affecting agriculture because, I think, there is more demand for the water . . . by business, homeowners, and other industry."

Drought planning and preparation tools also were mentioned. According to a state Extension faculty member, drought forecasting can be beneficial if used properly: "You can't do much once you are in a drought, but if you [know one is] coming, you can certainly be better prepared . . . the issue is to forecast drought in a reasonable time frame."

Given the susceptibility of the Southeast to drought (Asseng et al., 2013) and the subsequent pressures on groundwater reserves associated with irrigation (Coles & Scott, 2009), it is not surprising that drought was the highest ranked issue in the water scarcity category. Respondents recognized these realities, with many explaining how severe drought conditions affect crop yields and the subsequent increase in associated expenses.

Rainfall Patterns (11.5 mentions)

Rainfall patterns and timing was the second most frequently mentioned water scarcity issue. Lack of precipitation can be detrimental to crop yield when plants do not obtain a sufficient amount of water at the right time. As one state faculty member said, "You can have rainfall all through the year, but if you don't get it, say, for corn at tasseling time, when it's producing the ear . . . you won't make much of a crop."

According to some interviewees, recent rainfall patterns are seen as less predictable. One researcher noted, "The types of rainfall events that we have are different. Before, they were longer and more predictable, now perhaps less so." In an analysis of 60-year rainfall data, Wang, Fu, Kumar, and Li (2010) found that the "interannual variance of Southeast summer precipitation decreased from the early twentieth century to the 1960s and then started to increase afterward" (p. 1010). Such rainfall variability contributes to "exceptionally wet and dry summers" (Konrad et al., 2013, p. 9), presenting management challenges for farmers (Asseng et al., 2013).

Irrigation (8 mentions)

Although irrigation was frequently mentioned as a solution to water scarcity issues, some respondents addressed the inherent challenges of irrigation. One administrator said, "A lot of center pivot irrigation systems have been going in, so you have water issues, adequate use of water, efficient use of water, potential impacts on your aquifers." Other respondents also raised the issue of groundwater depletion, with one researcher saying, "There's more irrigation and so there's less groundwater available." A county agent also identified the issue of competing use, saying, "There's some people that are scrutinizing these water-use situations, and it creates a lot of debate and looking at agriculture and [farmers'] usage and [asking] 'do they really need to use that much?'"

Consistent with the respondents' attention to irrigation issues, Templeton, Perkins, Aldridge, Bridges, and Lassiter (2014) found that 33 of 49 Extension professionals reported that their clientele could use climate forecasts to improve irrigation management, the highest rated item of all possible management practices in the study.

Temperature (18 mentions)

Temperature was the second most frequently mentioned climate issue overall, with most respondents mentioning challenges associated with higher temperatures. A county agent stated, "Summers seem to be getting hotter and hotter. . . . It affects not only the crop, but . . . the soil moisture totally evaporates." A researcher said that "excessive heat, particularly . . . nighttime temperatures" was problematic, especially for cotton. Sustained high temperatures also were identified as a challenge. A county agent said, "Last year, we had about a week to 10 days in May that were above 100° temperatures, and that was very tough."

Other respondents focused on how temperature fluctuations and the lack of chill hours negatively affect the growing cycle of crops. A state Extension faculty member who noted that farmers are challenged by temperature fluctuation emphasized, "In many parts of our state, we have fruit which require a certain number of chill hours." According to Fraisse, Breuer, Zierden, and Ingram (2009), "If a crop variety is being grown in a climate near its temperature optimum, a temperature increase of several degrees could reduce photosynthesis and shorten the growing period" ("Potential Impacts of Climate Change on Agriculture," para. 3). Such increases in temperature, when combined with lack of precipitation "accelerate plant development, reduce grain-filling, decrease nutrient-use efficiency, and increase crop water consumption" (Anwar et al., 2013, p. 232).

Pests and Diseases (16 mentions)

Regarding pests and diseases, a county agent said, "What I think is the most important of these climate-related issues is what people can visibly see. And people can actually appreciate what's going on in their cropping system, and that has to do a lot with pests." Another county agent raised the issue of how drier conditions also can limit the efficacy of herbicides, saying, "If we remain dry during the planting season and do not get the moisture for those herbicides to be activated, then our back is against the wall from day one from a weed control standpoint."

The Southeast is predisposed to agricultural pest problems, resulting in relatively high pesticide use (Fraisse et al., 2009), and increased frequency of higher temperatures and more precipitation tend to lead to wet vegetation that increases growth of pests and diseases (Rosenzweig, Iglesias, Yang, Epstein, & Chivian, 2000).

Seasonal Variability (10 mentions)

Seasonal variability codes fell into three categories: the effects of El Niño and La Niña and long-term oscillations, weather changes from year to year, and the rate of change in the seasons. One researcher said, "I think the most frequent question is about the seasonal variation, the effect of El Niño and La Niña on issues related to planting or irrigations."

The respondents who mentioned changes from year to year did so in terms of the effects on planting seasons. An administrator summed up this concept: "I think the most pressing and current issue would be dealing with the weather variability, the weather risk that we have just within a 1-year growing season." Those interviewees who discussed seasonal change mentioned abrupt changes in the seasons and the lack of cold weather for vernalization of wheat or setting of fruit. A county agent said, "It seems that we don't have a gradual pattern of changing seasons anymore . . . it seems that we go straight from winter to summer, and straight from summer to winter."

The topic of seasonal variability is an interesting bridge between weather and climate change, anchoring discussions of climate in terms of weather, which is of primary interest to farmers, but also relating these seasonal weather conditions to larger climatic influences.

Information and Management Needs

Respondents articulated that both Extension professionals and producers need improved forecast information and adaptation strategies for dealing with climate variability and change.

Forecasts (12 mentions)

Interviewees stressed that agricultural decision makers need reliable, short-term weather forecasting. A county agent explained that farmers are "trying to make decisions on different chemicals, fungicide applications, and things like that."

When talking about seasonal forecasting, respondents focused on rainfall. One county agent remarked that clients frequently ask questions such as "How is the rainfall going to be this year?" and "Are we expecting kind of a wet summer and fall, or are we expecting an extremely dry one?" Two respondents emphasized the importance of forecast accuracy for summer rainfall, with an administrator saying, "If you could really predict the weather for the summer, that might change [producers] from planting corn to planting grain sorghum or something like that."

Overall, Extension professionals expressed the need for improved forecasts across all time frames: short-term weather, seasonal variability, and climate change. These findings are consistent with Cabrera et al. (2006), who reported that Extension agents in Florida agreed or strongly agreed that their work was affected by El Nino–Southern Oscillation (ENSO) events (88%) and that it would be helpful to know how the next season's climate would be different (93%). A South Carolina study of Extension professionals (Templeton et al., 2014) showed that forecasts that include freeze alerts, plant moisture stress, ENSO phase, and growing degree days would be the most useful to Extension professionals. If we in Extension expect farmers to make decisions based on forecasts, then the forecasts must be reasonably accurate and connected to specific recommended actions.

Adaptation (9 mentions)

Adaptation included mentions of planting dates, crop selection, and decision support tools. Those mentioning planting dates did so by discussing the need for farmers to be flexible in their planting dates in response to climate variability. A state faculty member said that planting dates are "a very critical issue for corn producers," especially for dryland farmers. Adjustments in planting dates were also discussed in terms of pest and disease management and planting earlier to avoid higher temperatures. A county agent noted that because of recommendations from a peanut specialist, farmers were planting peanuts earlier that year. The agent went on to explain that the recommendations to move up the planting of peanuts had been based on "tomato spotted wilt diseases and the warm temperatures."

Respondents pointed out that farmers need to adjust their crop selection in response to climate variability and its subsequent influence on water availability and temperatures. An administrator summed up the adaptation needs expressed by many respondents: "It changes your cropping systems because a lot of the crops that you can grow are tied to the season. If you have warmer springs, then you want to maybe fall back and plant certain crops earlier, and there may be the potential to double-crop some crops, some new crops, like sorghum."

Even though the interview questions specifically engaged respondents in identifying climate-related issues, respondents frequently indicated that management solutions were among their priorities. Morris, Megalos, Vuola, Adams, and Monroe (2014) discussed how Extension can fulfill its mission by addressing the "symptoms" of climate variability and extreme weather by focusing on "how best to use familiar management tools to maximize resource health, productivity, and resilience in changing future conditions" ("Successful Extension Climate Change Program Delivery," para. 2).

Conclusion

Our study revealed that Extension professionals consider scarcity of water resources, temperature fluctuations, pest and disease pressures, forecast challenges, seasonal variability, and adaptation strategies to be among the most important climate-related issues affecting agriculture in the Southeast. With more than 90% of Extension professionals interviewed believing climate change will continue to affect agriculture at least a moderate amount, a continued emphasis on management options for responding to climate variability is a practical strategy for climate research and education. However, other researchers have asserted that climate adaptation may have limited effectiveness in addressing large and unpredictable changes associated with long-term climate change and may even increase future vulnerability to climate change (Dilling, Daly, Travis, Wilhelmi, & Klein, 2015). In addition, researchers have argued that the direct provision of education to farmers is not the most efficient or effective way to deliver Extension knowledge, recommending that Extension instead serve as an intermediary between farmers and other agricultural advisors, making more efficient use of scare resources in the Extension system (Haigh et al., 2015; Prokopy et al., 2015). Regardless of whether training is provided directly to farmers or through intermediaries, we propose that Extension has a critical role to play in climate training and that the foundation for this knowledge rests on a clear understanding of the present issues facing farmers.

The Extension professionals interviewed focused on the immediate concerns of farmers, a scenario that is consistent with previous research that led us to conclude that climate training for Extension professionals should emphasize "basic climate concepts through applied agricultural examples tailored to both their content areas and the needs of their clients, enhancing the ability of Extension agents to address producer concerns" (Diehl et al., 2015, p. 40). Similarly, Morris et al. (2014) suggested that Extension should tailor climate information to clientele needs that enhance producer resilience and profitability. Beyond the specific issues in any given region, however, a larger lesson is that local and regional assessments of the climate-related agricultural needs of farmers should be conducted so that immediate farmer concerns define appropriate solutions-based content for Extension education.

Continued research on Extension's role related to climate variability and change in agriculture should include quantitative studies involving larger samples of Extension professionals and farmers, allowing for subgroup analyses and the analysis of relationships among variables. Such research might include more explicit attention to farmer beliefs about the ways in which climate affects agriculture and how Extension can best communicate with farmers to develop adaptation strategies that work in specific conditions. Given the results of our study, it seems important to include localized research identifying the climate issues of interest as well as localized evaluation of Extension's ability to engage farmers in adaptation strategies and, ultimately, to assess the effectiveness of these strategies.

Cooperative Extension has traditionally struggled to address potentially controversial topics such as climate change, which may conflict with the personal views of stakeholder groups and elected officials (Monroe et al., 2014). By linking discussions of climate variability and climate change to management strategies, Extension can reduce the possible tensions associated with the issue of climate change. This suggestion is consistent with previous research indicating that adaptation success is seen "when measures that address climate change risks are incorporated into existing decision structures related to risk management, land use planning, livelihood enhancements, water and other resource management systems, development initiatives, and so on" (Smit & Wandel, 2006, p. 289). Extension can play a critical role in identifying knowledge gaps, setting research priorities, developing adaptation technologies and risk management strategies, and disseminating these strategies to producers, helping them become more resilient in the face of climate variability and climate change.

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