Renewable Agriculture and Food Systems

cambridge.org/raf

Climate change and agriculture in New York and Pennsylvania: risk perceptions, vulnerability and adaptation among farmers

David Lane[1], Allison Chatrchyan[1], Daniel Tobin[2], Kaila Thorn[3], Shorna Allred[4] and Rama Radhakrishna[3]

[1]Cornell Institute for Climate Smart Solutions, Cornell University, Ithaca, NY 14853, USA; [2]Community Development and Applied Economics, University of Vermont, Burlington, VT 05405, USA; [3]The Pennsylvania State University, University Park, PA 16802, USA and [4]Department of Natural Resources, Cornell University, Ithaca, NY 14853, USA

Themed Content: Ag/Food Systems and Climate Change

Cite this article: Lane D, Chatrchyan A, Tobin D, Thorn K, Allred S, Radhakrishna R (2018). Climate change and agriculture in New York and Pennsylvania: risk perceptions, vulnerability and adaptation among farmers. *Renewable Agriculture and Food Systems* **33**, 197–205. https://doi.org/10.1017/S1742170517000710

Received: 14 July 2017
Accepted: 28 November 2017
First published online: 14 January 2018

Key words:
Adaptation; climate change; farmers; perceptions; resiliency

Author for correspondence:
David Lane, E-mail: del97@cornell.edu

Abstract

Climate change impacts on agriculture have been intensifying in the Northeastern United States. In order to encourage the adoption of climate change adaptation and mitigation practices by farmers, it is critical to understand their perspectives on the risks they face and actions they are taking. However, very few empirical studies have considered how farmers are interpreting and responding to climate impacts, risks and opportunities in the Northeast. This study investigates farmer views and decisions related to climate change using data from six farmer focus groups conducted across New York and Pennsylvania. The study examined how farmers perceived climate impacts on their farms, the practices they are willing to adopt, and how perceived risks and vulnerability affect farmers' decision-making related to adaptation and mitigation strategies. Although farmers articulated concern regarding climate impacts, they also made clear that other business pressures, such as profitability, market conditions, labor availability or government regulations were often more critical issues that affected their decision-making. Decisions about adopting climate change adaptation and mitigation practices vary widely, and personal experience with extreme weather and changing seasons affected decision-making. The findings from this study provide improved understanding of farmers' needs and priorities, which can help guide land-grant researchers, extension and policymakers in their efforts to develop and coordinate a comprehensive strategy to address climate change impacts on agriculture in the Northeast.

Introduction

As a global phenomenon, climate change has varying impacts on different sectors across different regions. In the Northeastern United States (US), evidence exists that climate change is already affecting the agricultural sector. These changes include increasing average temperatures, more frequent and intense extreme precipitation events, and longer growing seasons (Kunkel et al., 2013). The impact of these climate change manifestations on agriculture will likely include reduced productivity of crops and animals, shifts in the timing of planting and harvesting, invasions of new pests and pathogens, and diminished resilience of agroecosystems (Tobin et al., 2015). Indeed, farmers have already felt the impacts. For example, New York (NY) grape producers in both 2007 and 2012 suffered yield losses when frosts occurred in the late winter after abnormally warm temperatures had encouraged early bloom (Horton et al., 2014). Although substantial risks exist for Northeastern farmers, new opportunities are also emerging. For instance, farmers in the Northeastern US may have greater opportunities to grow different crops or varieties than the ones they have traditionally cultivated due to longer and warmer growing seasons, and expectations exist that the region will continue to be rich in water resources (Wolfe et al., 2011).

Although the biophysical sciences have been documenting the impacts of climate change on agriculture in the Northeast, far less attention has been dedicated to understanding farmer perceptions and priorities of climate change. In their comprehensive literature review, Chatrchyan et al. (2017) found that among 84 studies addressing US agricultural stakeholder views and decisions related to climate impacts, risks and opportunities, only four focused on the Northeastern region. The few studies that have been focused on the Northeast suggest that farmers in the region are adapting to climate change but are much less willing to mitigate it by reducing greenhouse gas emissions or sequestering atmospheric carbon dioxide (Jemison et al., 2014; Kuehn, 2016; Schattman et al., 2016). Because expert knowledge generated by climate science is not guaranteed to translate to adoption among farmers (Walthall, 2012; Prokopy et al., 2015), understanding the factors that motivate or prevent farmers from adapting to and mitigating climate change is critical. Indeed, several studies have concluded that the climate change information generated by scientists must be made more relevant to local contexts

CAMBRIDGE UNIVERSITY PRESS

for farmers to find it useful and applicable (Bartels et al., 2013; Mase and Prokopy, 2014; Brugger and Crimmins, 2015; Tobin et al., 2017). The importance of taking farmer perspectives into account was highlighted by Schattman et al. (2016), who documented how personal experiences with climate-related events inform risk perceptions to help determine adaptation actions among Vermont farmers. Arbuckle et al. (2013) found that those farmers who accept anthropogenic climate change are more amenable to adaptive and mitigative action than skeptical farmers. Relatedly, Haden et al. (2012) conclude that the long-term and societal impacts of climate change motivate farmers to implement mitigation strategies, while localized concerns encourage adaptation.

This study helps to address the dearth of literature on farmer perspectives of climate change in the Northeastern US by focusing on NY and Pennsylvania (PA) farmers' experiences and perceptions of climate change. Although NY and PA have the strongest agricultural economies in the Northeast, as indicated by market sales of agricultural products among Northeastern states (NASS, 2014), very little has been written about farmer perceptions of climate change in these two states. We therefore seek to shed insight into the experiences that farmers in NY and PA are having with climate change, focusing on their articulations of specific climate impacts, if and how they are adapting to and/or mitigating these impacts, and their reasons for doing so. In examining farmer perceptions of climate change and their responses, this study is based in the conceptual understanding that perceptions of vulnerability and risk are key factors underlying adaptation and mitigation (Arbuckle et al., 2013; Schattman et al., 2016; Mase et al., 2017).

Conceptual framework

The concept of vulnerability is useful when considering farmer perceptions of climate change (Schattman et al., 2016). Although a great deal of attention has been dedicated to defining vulnerability and many variations exist, for the purposes of this paper, vulnerability is considered to be comprised of exposure, sensitivity and adaptive capacity (Smit and Wandel, 2006). Exposure refers to the kinds of impacts and their intensities to which a system is subjected; sensitivity is the degree to which these impacts affect the system; and adaptive capacity is characterized as the potential for the system to maintain resilience when confronting climate stresses (Below et al., 2015; Sietz et al., 2012). Importantly, it must be noted that the vulnerability in a particular situation is determined by both biophysical and social processes (Adger, 2006).

Although activity-based indices are often utilized to measure vulnerability, perceptions of climate change are also important to consider because actions are predicated on farmers' understandings of the threats that exist (Maddison, 2007; Arbuckle et al., 2013). Frequently, studies analyze farmer perspectives of climate change in terms of risk perceptions. For instance, Mase et al. (2017) outline the case for considering risk perceptions of climate change among farmers, documenting that how farmers perceive risk is an important determinant of their willingness to pursuing adaptation or mitigation strategies. Likewise, both Bartels et al. (2013) and Schattman et al. (2016) conclude that risk perception of climate change is an important factor that precedes adaptive or mitigative action. For the purposes of this study, risk is defined as 'the potential for adverse consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values' (USDA, 2016, p. 60).

As indicated above, farmer perceptions of climate change are critical to consider because they are an important factor underlying adaptive action. Mase et al. (2017) develop a conceptual and empirical link between climate change beliefs, risk perceptions and adaptation among Midwestern farmers. An adaptation may be considered as an 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which reduces vulnerability, moderates harm, or exploits beneficial opportunities' (USDA, 2016, p. 60). According to Smit and Wandel (2006), adaptations can be seen as evidence of adaptive capacity and therefore vary depending on the specific vulnerability context. Although adaptation behaviors can be anticipatory or reactive, they are responses to changes that are perceived as occurring. In contrast, mitigation seeks to reduce the drivers of climate change by reducing the greenhouse gas sources and increasing their sinks (USDA, 2016). However, most studies find that adaptive behavior among farmers is much more common than mitigative behavior, likely due to mitigation action being predicated upon belief in anthropogenic climate change, whereas adaptive behavior adheres to the fundamental necessity of adapting agricultural systems to weather variability (Walthall et al., 2012; Chatrchyan et al., 2017).

Methods

This study assesses farmers' perspectives of climate change through six farmer focus groups conducted in NY and PA. As the leading agricultural states in the Northeast in terms of both production and market sales (NASS, 2014), we chose to implement a criterion sampling strategy, which selects participants based on their fulfilling a particular criterion (Patton, 2001). For the purposes of this study, the criterion of importance was based on the production of particular agricultural commodities relevant to NY and PA. NY is a top-ten national producer of cow's milk, apples, grapes, onions and sweet corn, and PA is a top-ten producer of dairy products and fruits (e.g., apples, peaches and grapes), and both states are leading producers among Northeastern states of beef cattle, broilers and forage crops (NASS, 2014). Therefore, criterion sampling focused on identifying farmers who cultivated vegetables, fruits, field crops and forage, as well as farmers who raise livestock for dairy and meat. Recruitment of focus group participants was facilitated by extension specialists who worked with producers meeting the criterion. Based on the specialists' recommendations, researchers contacted the producers by email to recruit for each focus group.

A team of researchers conducted six focus group discussions with farmers in NY and PA, with three groups in each state. In total, there were 35 participants—32 males and 3 females. The farmers in this study had been farming for 22 yr on average. Farm size ranged from 6.5 to 3500 acres. Each focus group targeted a diverse range of producers including economically important agricultural commodities in the two states. Using NASS (2014) data, we targeted key commodities, with the understanding that many farmers produce more than one type of commodity, especially with the increasing diversification that comes as an adaptation response to climate change. Table 1 provides an overview of the focus group participants.

The focus group interview guide (see Appendix 1) was developed by the authors of this study and screened by a panel of experts consisting of faculty members with both technical expertise in crop and animal production, as well as methodological expertise in qualitative methods. The interview guide included eight questions, though it was developed to be semi-structured to allow facilitators to probe interesting ideas based on the discussion with each specific producer group.

https://doi.org/10.1017/S1742170517000710 Published online by Cambridge University Press

Table 1. Climate change focus groups conducted in New York (NY) and Pennsylvania (PA) in 2016

Focus group[a]	Location	Date	Participant totals	Gender
Mixed farmer group (PA-MIXED): meat, vegetables, dairy	State College, PA: Pennsylvania Association for Sustainable Agriculture (PASA) Conference	2-6-16	8[b]	5 male 3 female
Mixed farmer group (NY-MIXED): vegetables, field crops	Big Flats, NY: NRCC Big Flats Plant Materials Center	4-21-16	5	5 male
Tree Fruit (PA-TREE FRUIT)	Gettysburg, PA: Adams County Extension Office	6-15-16	3	3 male
Dairy (NY-DAIRY): dairy, forages	Canton, NY: CCE St. Lawrence County Office	6-28-16	5	5 male
Field Crops (PA-FIELD CROPS): corn, hay, soybeans	Pennsylvania Furnace, PA: Ag Progress Days	8-17-16	7	7 male
Grape (NY-GRAPES)	Portland, NY: Lake Erie Regional Grape Program Office	9-8-16	7	6 male 1 female

[a]A mixed farmer (vegetables and specialty crops) focus group was held at the NOFA NY conference in Saratoga, NY with four farmers on January 23, 2016 as a pilot focus group for the entire study.
[b]There were three participants in this group (PA-MIXED) who were not from PA. They were from NY, Wisconsin and Delaware, respectively. However, any direct quotations written in this paper were taken only from the five participants who were from PA.

It is important to note our approach to document perceptions of climate change impacts for several reasons. Because climate change is a long-term, multi-decadal phenomenon, it is difficult to measure individuals' perceptions in the here and now. Other researchers, confronting a similar challenge, have asked farmers about variable or extreme weather (Jemison et al., 2014; Mase et al., 2017), given that this is a manifestation of climate change. While we recognize that single weather events cannot necessarily be attributed to climate change, the focus group questions asked farmers to consider a 10-yr time frame, a substantial amount of time for multiple extreme weather events to occur. To explore elements of vulnerability (exposure and sensitivity), the focus group participants were asked to reflect on the impacts of extreme weather events in the last 10 yr. To better understand risk perceptions, respondents considered their primary concerns related to their farming operations, both climatic and non-climatic. Questions regarding adaptation practices and the reasons for adopting practices, including climate change beliefs, also reflected adaptive capacity. Finally, the focus group participants were asked about their willingness to adopt mitigation practices that reduce greenhouse gases on the farm. The interview guide was pilot tested in one mixed farmer group with small-scale vegetable and organic producers at the NOFA-NY conference in Saratoga Springs, NY. Based on the feedback from the pilot focus group, the questions were revised to clarify their meaning and improve their flow.

The focus groups were conducted from February to September 2016, lasted approximately 60–75 min, and were audio recorded and later transcribed for analysis. Institutional Review Board (IRB) approval was granted from both Cornell University and Penn State University for the study. Based on a literature review, an *a priori* coding framework to guide the coding process was developed. Although the framework provided an initial structure for analysis, we allowed for codes and themes to emerge inductively, updating the coding framework accordingly. Analysis was performed using ATLAS.ti 7 software. We employed an axial coding procedure (to identify relationships and connections among the codes) and to examine the key concepts and themes that emerged from the participants in each group (Corbin and Strauss, 1990). To represent the themes conveyed by farmers, particularly compelling direct quotations were selected for analysis (Weiss, 1994). As a validation strategy, we conducted an intercoder agreement, whereby each focus group transcript was analyzed by two coders to ensure consistency in interpretation (Creswell, 2007). Through multiple coders, a coding framework and research question memos, our analytical approach ensured transparency, reproducibility and ultimately credibility to our results (Meyrick, 2006; Friese, 2014, p. 171; Corbin and Strauss, 2015, p. 344).

Results

The results from responses during the six focus groups are presented below as they relate to the key themes that emerged during analysis: climate change impacts on the farm, adaptation and mitigation decision-making, climate change beliefs, and climatic and non-climatic risk perceptions.

Climate change impacts on the farm

Farmers participating in both the NY and PA focus groups noted an increase in extreme weather events that had occurred on their farm in recent years and have observed changes in the climate over the years they have been farming. Participants across all six of the focus groups noted shifts in seasons (usually characterized by shorter winters and longer growing seasons), changes that were encapsulated by one farmer who summarized that 'there just isn't a normal season anymore'. An increase in extreme precipitation events also received extensive attention from all six of the focus groups. These extreme precipitation events often led to flooding and wet fields. In addition, participants in five out of the six groups were concerned about drought, especially when they had experienced it personally. Participants in three out of the six focus groups experienced intensified biological stressors such as pests and weeds, though this was most commonly articulated among producers in the PA focus groups, who indicated that warmer and more varied winter temperatures likely contributed to the intensified presence of pests like slugs.

Frequently, farmers in both the NY and PA groups noted that they had been confronting several of these different weather events. To illustrate these experiences, a field crops farmer in a PA focus group explained that both drought and flooding had affected his farm:

- We've experienced a lot of different things. You know, from drought, to in like 2011, we had 400 acres of corn underwater

https://doi.org/10.1017/S1742170517000710 Published online by Cambridge University Press

because of extreme moisture, and the river came out at the banks.

Issues with flooding were not unique to farmers who cultivated grains. In the NY grapes focus group, one farmer also indicated that extreme rainfall had been problematic to his operation:

Last year we had 7″ of rain in 24 h, and it flooded one of our vineyards…the creek came through and flooded one of our vineyards right out.

Although climate impacts are often negative for agricultural production, there can also be some opportunities for farmers. As noted by Tobin et al. (2015), the Northeastern US is expected to have increasingly long and warm growing seasons that may alter timing for planting and harvesting. One field crops grower in the PA focus group noted that the harvest time for corn had been changing, which he perceived as having at least some benefit:

- Another trend that I think I've seen on our farm, I remember, as a kid, you know, 30, 40 years ago, we were always picking corn in Thanksgiving, and I haven't picked corn in Thanksgiving for 20 years,…that's another indication, you know, that we do have a little more warmth, a little more heat. We are getting things off earlier, and then, there are actually some advantages,…

Another illustration of an emerging opportunity resulting from climate change was articulated by a PA tree fruit grower, who indicated his ability to expand the crops he cultivated:

- …the only real impact I can see from any climate change is that we are more able to get a regular crop on some of the soft fruit like apricots and plums…My grandfather didn't even raise apricots because they couldn't get apricots. They froze every year. They bloomed too early.

Nuanced perceptions of on-farm climate impacts also emerged through discussion of microclimates. As farmers observed, particular weather events did not have a homogenous effect on their crops. Instead, the severity of the event depended on crop location and microclimates. This was most clearly articulated by a NY grape producer, who explained how late frosts in the spring had varying impacts on his farm:

- But for my little operation it turns out that the spring bud freeze damage is significant and two-thirds of our grapes are on this side hill, well fortunately they don't freeze on the side hill, but on the flat they freeze.

Due to the effects of these microclimates, the farmers indicated a need for more site-specific and production-specific information on how the climate was going to change over time, which could help them adapt to these climate and microclimate impacts.

Adaptation and mitigation decision-making

Farmers in all six focus groups indicated they were adapting to extreme weather events by preparing for future recurrence of extreme events that had negative impacts in the past. The following adaptation practices appeared to be the most prevalent among the farmer participants: shifting planting dates, changing plant varieties, diversifying crops, installing tile drainage, utilizing cover crops and switching to reduced tillage or no-till practices. For instance, to adapt to extreme flooding events, one farmer in the PA field crops group no longer planted soybeans in the lower elevation areas of his farm that flood. In response to increased pest pressure that farmers assumed resulted from shorter, warmer winters, some farmers, especially in the PA focus groups, described the use of more pest control measures, including integrated pest management and the use of insecticides. This was explained by one field crops farmer:

- Pests, you know, we're probably using more insecticide because of the winters being more mild, and we're having more pest control. So, probably using more insecticides than we used to, trying to help control, control the insects.

A PA farmer in the mixed farmer group who raises sheep decided to switch to a breed that is more resistant to both increased pest pressure and hoof rot:

- I've changed over to a different breed of sheep, to Katahdin, for a number of reasons. With the warmer weather, you see greater parasite pressure, and it's getting to the point that parasite resistance is rampant….the Katahdins are somewhat genetically resistant anyway. I have no more hoof rot with that breed.

Unlike field crops growers in the PA focus group, who explained that they had experimented with new crops or varieties to adapt to the weather events they had experienced, grape and tree fruit growers could not so easily adapt by planting new varieties from season to season, shifting planting dates, or moving planting locations; grapes and tree fruits are perennial crops and are therefore viewed as a relatively permanent investment. For these farmers, options to adapt their operations were considerably more limited. For example, one NY grape farmer had to work with an excavator to remove debris and deposition such as driftwood and rocks from the vineyard and the creek after an extreme rainfall event led to flooding and excessive deposition. This farmer went on to explain that the runoff from these extreme precipitation events becomes amplified, potentially causing even more damage:

- We get all of the runoff…the main creeks that come through… are normally little creeks. Well, when you get 7″ of rain, [and] they become these huge gushing creeks and just take over…

To adapt to these floods, several grape growers described having to redo driveways and add culverts.

As farmers described their on-farm adaptations, they made clear that these changes in management practices were primarily made to reduce risks to profitability. In other words, the adaptation measures the farmers were implementing were viewed primarily through a profit lens, as opposed to, for example, ecological or social resilience. For example, a NY dairy farmer who had invested in tile drainage (a subterranean drainage system used to remove excess water from agricultural soils) indicated:

- But on the years you need them (chuckle), tiling ground, tile drainage…[it's like] money in the bank.

Similarly, another farmer mentioned that tile drainage is 'an investment', which pays dividends when it helps avoid severe damage. Another dairy farmer stated that NY dairy farms have a competitive disadvantage regarding heat stress compared with states further south such as PA:

https://doi.org/10.1017/S1742170517000710 Published online by Cambridge University Press

- …heat stress drives me nuts on the dairy end of things because our risk factor for heat stress management is critically lower, but it costs just as much to mitigate it. We're at a competitive disadvantage this far north because how many days of the year do I really need sprinklers and fans compared to a dairy even in Pennsylvania or go further south, but yet it costs me just as much…

The emphasis on profit among farmers was concisely summarized by one NY vegetable grower:

- …well the changes we've made have not been because of climate change as per se, but for economic reasons…

Regardless of why decisions are made, many farmers were adapting to climate change. However, most of the focus groups participants were not yet intentionally adopting practices to mitigate climate change. Very few farmers in the focus groups had installed renewable energy on their farms, such as solar panels, windmills or biogas/biodigesters. There were only three instances of farmers mentioning intentional carbon sequestration (such as through soil health improvements), and carbon sequestration was only discussed in two of the focus groups. Often, the reason for not adopting mitigation practices had to do with the high costs associated with installing new technologies. One grape grower in NY field crops grower stated,

- We looked at solar farming except for the price that they were willing to pay [for the electricity produced]…we [would have] had to tear vineyards out [to afford this investment and create the space for the solar panels].

In this case, the opportunity cost of taking vineyards out of production to produce electricity with solar panels was too high to justify the solar installation. In general, profitability was a high priority which determined many farm management decisions. A NY vegetable grower summarized the importance of profitability and economics when making on-farm decisions related to using cover crops to improve soil health:

- The difficult step is the initial investment [in the costs] of the cover crops…because most people want to see an immediate return [on their investment].

Climate change beliefs and perceptions of anthropogenic climate change

Given that previous studies have documented how climate change beliefs influence adaptation and mitigation among farmers (Arbuckle et al., 2013; Mase et al., 2017), focus group participants were asked to articulate their beliefs in climate change and perceptions of anthropogenic climate change. As a group, farmers are often more skeptical of human-caused climate change than the general US population (Howe et al., 2015), a sentiment that was articulated by some of the participants. One PA field crops farmer expressed doubt regarding the impacts humans were having on the climate:

- …I think the strongest thing that I would argue here is I hear people say, climate change is man-made. I will absolutely, positively disagree with that because if you go back through the climatic records, and look at it, there has always been climate change.…10,000 years ago we had glaciers in North America.…we do have climate change. Is human activity affecting it?…I think I would use the word affecting rather than causing. I don't like the word causing.

Other farmers shared similar sentiments but framed their beliefs in the power of natural systems. In four out of the six focus groups, farmers mentioned Mother Nature to explain changes. Their comments seemed to suggest inevitability to climate change that was beyond the control of human activity in general and farmers in particular. As a PA tree fruit grower articulated:

- …that response from us as a grower group comes because of our perspective and respect for Mother Nature, knowing that it's something we can't change. You know, whether we're doing it or not, we're not going to change what has already happened up until now, at least in the time frame that matters to any of us.

This view, that Mother Nature is an unstoppable force, indicates a certain degree of resignation, one that may be open to adapting to changes that are occurring but not to proactively taking measures to mitigate climate change.

Still other farmers were more receptive to the possibility that climate change was a human-caused phenomenon. Though they did not express a high degree of concern, they nonetheless indicated that their on-farm management decisions should be informed by sound understanding of the causes of climate change. One PA tree fruit farmer represented the sentiments of many of the focus group participants regarding the influence of perceived climate change risks on decision-making in the following manner:

- My personal feeling is that our climate is changing. I'm less alarmist than many, but understanding more why and how may help us make better decisions for the future.

Thus, across the farmer participants, beliefs in anthropogenic climate change varied, but each of these perspectives had implications for the kinds of decisions farmers would be willing to implement on their farms.

Climatic and non-climatic risk perceptions

To understand how farmers were prioritizing climate change in their decision-making, they were asked to reflect on what they perceived as the primary risks to their operations. Although concerns about climate change were articulated by most farmers, issues related to profitability and regulations were also prominent concerns. Dairy farmers consistently highlighted excessive regulation as a concern, a perspective supported by many tree fruit and grape growers. The relative lack of perceived risk that farmers placed on climate change was well represented by a PA tree fruit grower, who was more concerned with labor shortages:

- …climate change doesn't come real high up on the priority list…I don't know that anyone sitting here…would list climate change as one of the top 10, or maybe not even the top 20, issues that we deal with on a daily, weekly, [or] annual basis. Labor's probably always at the tip of our tongue…I think that's at the top five for everybody.

In addition to perceived risks associated with labor, profitability, and excessive regulations, there was an emergent theme regarding the perceived risk of an 'ignorant society', which can be interpreted as the perception that common citizens do not

https://doi.org/10.1017/S1742170517000710 Published online by Cambridge University Press

adequately understand agricultural production. Concerns regarding the ignorance of consumers were expressed in four focus groups, but most frequently in the dairy, field crops and tree fruit focus groups. One field crops grower in PA aptly summarized this issue:

- My major concern is…I want to use the word ignorant, but I don't want to mean it in a bad way. An ignorant society…My generation doesn't know anything, and my kids' generation is far worse. And they'll buy into anything they see…they read or see that is the politically correct answer. They're all anti-pesticide, 'We can do all of this organically,…why are you spraying?' And we need these tools to manage these pests, and the pests that we've had. And nobody seems to understand what a wonderful job the EPA has done of getting rid of the really, really nasty stuff…

This farmer was very concerned that society was being informed more by the media and politics than science, and that this trend could change consumer demand to the extent that he could be put out of business. Another tree fruit grower expressed similar sentiments:

- …Only two percent of the population is directly connected to agriculture anymore. And I think you're going to find out with all…of us in agriculture. I know the dairy people run into the same thing. The bee people run into the same thing. You know, red meat's going to kill you. Eggs are bad for you…And just the lack of education…But the speed that the lack of education moves today is a real, real big challenge for us.

Thus, just as farmers were motivated to adapt their farms for economic reasons, their concerns about what society understood about agriculture also appeared to be primarily framed from a financial perspective. Of particular concern was the potential for society's perceptions of farming practices to affect consumer demand, and in turn, profitability.

Although farmers extensively commented on the importance of non-climatic risks, they did also indicate concerns about climate change. From the perspective of several PA tree fruit growers, farmers need to consider multiple risks simultaneously, including climate change. One grower, for example, perceived that his decision-making about varietal selection needed to address climatic threats, public perceptions and regulations all at once:

- The pests had pretty much stayed the same. We didn't have a lot of invasive species like we do now….now, growers, I think, are having to adapt to all these societal changes, the public's perceptions, new regulations and stuff like that. So your long-term thoughts now are, okay, I plant this tree and I want to…[know], is it going to be a good [variety] in 15 or 20 years?

Grape growers shared similar concerns about the importance of variety selection because the vines, like fruit trees, are perennial, and it takes several years to produce a harvest after replanting. Therefore, the farmers of perennials had fewer perceived adaptation options than vegetable growers or dairy farmers. However, vegetable farmers most commonly expressed concerns related to climate risks. Despite having more adaptation options than grape or tree fruit growers, vegetable growers more readily voiced concerns about vulnerability to extreme weather events and climate-related impacts than the other growers. Vegetable producers perceived their crops as vulnerable to climate impacts such as extreme precipitation and changing seasons. Thus, despite the fact that the climate risks were often subsumed under profitability risks, many of the farmers were at least considering climate risks, especially vulnerability to extreme weather events, in their decision-making.

Discussion

The findings from this study suggest that the focus group participants in NY and PA are indeed experiencing the impacts of climate change on their farms. Therefore, as per Smit and Wandel's (2006) conceptual framework of vulnerability, the focus group participants in this study were both exposed and sensitive to many climate-related impacts, which had implications for their adaptive capacity. However, as will be discussed below, the elements of vulnerability—exposure, sensitivity and adaptive capacity—varied among individual farmers and across focus groups.

From the perspectives of exposure and sensitivity, the focus group participants indicated that the impacts most severely affecting their operations were changing growing seasons, extreme precipitation events, drought and flooding. These climate impacts align with the ones that have been projected to most seriously affect agricultural production in the Northeastern US (Kunkel et al., 2013; Tobin et al., 2015). Together, these articulated experiences of on-farm impacts from extreme weather events indicate that the focus group participants perceived that they are exposed and sensitive to climate change, whether or not they frame these impacts in those terms. In particular, extreme precipitation events and the flooding that often results appear to be the phenomenon to which, at least to date, farmers feel most vulnerable, aligning with previous findings in the Northeastern region (Schattman et al., 2016). However, exposure and sensitivity also seem to vary across locations. For example, intensified pressures from biological stressors were identified as a vulnerability by farmers in the PA focus groups, but interestingly were not mentioned by farmers in the NY focus groups. This may be due to the expectation that shorter, warmer winters will likely encourage the northward migration of invasive weeds and pests (Tobin et al., 2015). Even though many of the impacts these farmers experienced had negative consequences on their agricultural production, the participants also recognized potential benefits and opportunities with a changing climate—particularly with the issue of longer growing seasons. In addition, their descriptions of how microclimates translated to differing impacts on crops from particular extreme weather events has implications for the geographic scale by which adaptation strategies should be considered. Providing regional, county-level or even farm-level recommendations may still not be targeted enough; instead, at least based on the perspectives of the focus group participants, the effectiveness of adaptation strategies may be most relevant at the field level in some cases.

Although the focus group participants indicated that their operations were both exposed and sensitive to climate change, they also provided evidence that they possessed adaptive capacity. As indicated through the focus groups, the farmers have begun to implement many of the adaptations that have been highlighted as relevant to the region, including shifting planting and harvesting dates, experimenting with new crops or varieties, improving drainage, utilizing cover crops and switching to reduced tillage or no-till practices (Tobin et al., 2015). As noted in previous studies (Liu et al., 2014; Schattman et al., 2016), the findings from this study support previous evidence that personal experiences with extreme weather events are a prime motivator for adaptation.

https://doi.org/10.1017/S1742170517000710 Published online by Cambridge University Press

However, adaptive capacity varies across commodities. For example, the NY and PA grape and tree fruit growers, as farmers of perennial crops, perceived they had fewer options to adapt than farmers of annual crops, who could more easily experiment with new crops, varieties or methods. Although adaptations are generally viewed as positive actions that farmers take, the findings from this study indicate that some adaptation activities may actually introduce unintended negative consequences. For instance, as pest invasions become more frequent and intense, farmers noted that they were increasing their insecticide applications, a finding that supports Wolfe's (2011) concern that increased use of insecticide due to intensified pest pressure may hurt farmers economically and contribute to environmental degradation. Thus, even though having many adaptation options available is undoubtedly positive, it is not necessarily uniformly so. One potential approach to prioritizing various adaptation strategies would be to evaluate the consequences that specific adaptations may generate from economic, environmental and social perspectives.

The geographic location and type of commodities produced influenced the farmers' adaptive capacity, and so did their climate change beliefs. Given that most of the farmers in this study explained that their adaptations were mostly inspired by personal experiences with extreme weather events or climatic changes, these findings suggest that the farmers in this study were adapting in a reactive, rather than an anticipatory manner. As a result, the farmers were limiting the number of adaptation options they were willing to consider, thereby reducing their adaptive capacity and increasing their potential exposure and sensitivity to future events they had not yet experienced. Although some of the adaptation strategies selected by NY and PA farmers like no-till may also contribute to mitigation, the sequestration of carbon was coincidental, not purposeful. These farmers' perspectives toward mitigation were not surprising, given that Haden et al. (2012) found that localized concerns typically drive adaptation, whereas mitigation is a concept tied closely to belief in anthropogenic climate change and perceived economic benefits. As previous studies have found (Arbuckle et al., 2013; Mase et al., 2017), climate change beliefs appear to underlie the kinds of on-farm actions taken by farmers. Chatrchyan et al. (2017) summarize that adaptation measures do not require a belief in anthropogenic climate change, but mitigation efforts do, which the findings from this study support. Many farmers expressed skepticism of anthropogenic climate change, and while they clearly adopted adaptive practices, they were generally not adopting mitigative practices. This has implications for agricultural resiliency, both now and in the future. If, as the findings from this study indicate, climate change beliefs are linked to the type of action (adaptive or mitigative) farmers are willing to take, they are then limiting the suite of options to confront climate change. As Schattman et al. (2016) note, failure to undertake mitigation is problematic, both in achieving national emissions reductions targets and in preventing future extremes of climate change. In other words, lack of mitigation efforts now will likely mean that the ability of farming operations to remain resilient to climate change (adaptive capacity) will be reduced in the future.

Although personal climate change beliefs do appear to inform farmer actions, their influence on adaptation practices should not be overstated. Indeed, Niles et al. (2016) reported that farmers' intentions to adapt to climate change do not often translate to actual adoption in some contexts. Furthermore, the findings of our study indicate that the focus group participants often prioritized financial concerns when evaluating whether an adaptive or mitigative practice is worth the investment. Although the dairy farmer participants could financially justify installing tile drainage, other farmer participants indicated that investing in solar panels or cover crops was simply cost prohibitive. These farmers' emphasis on financial concerns supports Tobin et al.'s (2017) finding that land-grant researchers and extension professionals perceive that a substantial barrier to on-farm adaptation is farmers believing that the costs of doing so are too high. These financial concerns again have implications for adaptive capacity: if farmers perceive that the costs of implementing new techniques or technologies are too high, farmers will be limited in their options to adapt to or mitigate climate change. In turn, failure to incorporate new techniques or technologies may exacerbate vulnerability in the future as climate change intensifies.

Economic and financial concerns among farmers were not limited to climate impacts on their farms. According to the focus group participants, climate change did not pose the greatest risk to their farms. Instead, focus group participants perceived vulnerability in their long-term economic viability due to misinformed societal assumptions about agriculture and burdensome regulations. Although farmers in this study were implementing many practices that increase climate resiliency, such as adopting no-till or planting cover crops, economic motivations, not climate change, were the primary driver of these decisions. Based on the perspectives of the farmers in this study, it appears that the participants are more likely to take anticipatory action only if they perceive it will financially benefit them; reductions in climate risk and/or other perceived risks are secondary benefits. Thus, as noted by Tobin et al. (2017), adaptation and mitigation strategies that simultaneously address multiple concerns are worthwhile to pursue. For example, adaptation to flooding *and* profitability may be well received among farmers. Consequently, both communicating the existing adaptation and mitigation strategies that have multiple benefits and developing new strategies with multiple benefits provides an approach in need of pilot testing to ease the economic worries of farmers.

Limitations of our study

This qualitative research study examined the views and perceptions of 35 farmers in six focus groups in NY and PA. Given the small sample size, the findings need to be interpreted with care. We view the findings of this study as exploratory and they should be further assessed as future studies continue to build the emerging evidence on farmer perspectives on climate change in the Northeast. As a qualitative study, the intent was not to generalize but to provide rich description, particulars and specifics from the participants (Creswell, 2013). In the future, qualitative studies exploring similar themes should expand the sample size to diversify and saturate perspectives and ensure that the voices of demographic sub-categories (race, gender, etc.) are considered (Creswell, 2007). For future quantitative studies, random sampling that covers the diverse range of agricultural commodities produced in the locations of interest should be pursued to ensure generalizability. Despite the limitations, the findings nonetheless provide important insight. Future studies that utilize the themes which emerged from this study will be based in solid initial evidence.

Conclusion

This study contributes to a better understanding of how farmers in NY and PA are perceiving risk and reacting to climate change. Framed in terms of the linkages that are theorized to exist among

https://doi.org/10.1017/S1742170517000710 Published online by Cambridge University Press

vulnerability, risk, adaptation and mitigation, the findings in this study indicate that farmers are indeed perceiving vulnerability to, and risks from, climate change. However, the skepticism toward anthropogenic climate change, financial and economic pressures, and risk perceptions about non-climate-related concerns appear to be limiting the extent to which farmers are willing to consider adaptation practices and appear to be limiting the adoption of mitigative actions. As a result, these findings offer initial evidence that farmers are at risk of increasing their vulnerability as climate change intensifies in the future.

Given that programming focused at the local level will most likely encourage adaptation behavior instead of mitigative action (Haden et al., 2012), researchers and extension professionals should consider specific strategies that simultaneously achieve both adaptation and mitigation. For instance, no-till practices may reduce the impacts of flooding and soil erosion (adaptation) but can also sequester carbon (mitigation) (Tobin et al., 2015). Furthermore, considering how to bundle the benefits of adaptation practices in a way ensures that multiple benefits come from a single practice is also essential. Some practices such as cover cropping, reducing tillage, reducing on-farm energy use and developing local markets offer multiple benefits and are considered sound and sustainable practices that farmers should consider adopting regardless of how they view the idea of climate change (Jemison et al., 2014). Interdisciplinary research and programming must identify strategies that not only pursue adaptation and mitigation at the same time but also other concerns such as profitability and productivity. These recommendations are also relevant at the policy level. For example, subsidizing conservation farming practices may be attractive to farmers economically but can also serve the joint purpose of encouraging adaptation/mitigation practices. Likewise, policies that strategically promote the link between certain farming practices and climate change adaptation/mitigation to the general public may help generate demand for agricultural goods farmed according to climate-smart techniques and thereby help ease farmers' concerns that a misinformed public is a threat to their livelihoods. However, the viability and effectiveness of these types of programs and policies must be researched and subsequently evaluated, given that some farmers, especially climate deniers, may view any policy promoting climate-smart techniques as rooted in misinformed beliefs about climate change. Regardless, the primary point is that adaptive and/or mitigative action will most likely occur if farmers perceive that their economic needs and other concerns are being addressed. Thus, developing and communicating strategies that bundle benefits in a way that ensures that multiple benefits come from one practice is of utmost importance for future research and educational endeavors.

The findings from this study make clear that important similarities and differences exist across different types of farmers. In this study, the farmers of different commodities and across different geographies experienced climate change differently and research should continue to explore these characteristics, in addition to other factors such as production techniques (e.g., organic and conventional). Furthermore, because risk and vulnerability are structured not only due to biophysical processes but also social ones, studying demographic characteristics (gender, socioeconomic status, ethnicity, race, etc.) provides another essential research endeavor to understand if and how experiences, barriers and opportunities vary among different farmer demographics. Continuing to conduct qualitative studies will be important for in-depth explanations of farmer decision-making, but survey-based studies that are able to achieve generalizability to specific populations are also necessary to provide further credence to these findings. Although the findings from this study should be interpreted with care, they provide important groundwork for future studies to build upon, so that farmer perspectives are both better understood and taken into consideration as the agricultural sector in the Northeast continues to adapt to climate change impacts.

See Appendix 1 for the Interview Guide used in this study.

Acknowledgements. This work was supported by the USDA National Institute of Food and Agriculture, Hatch Multistate Research Project (Accession Number 1011252) and a USDA Agricultural Research Service Cooperative Agreement with Cornell University (58-1902-4-010) for the Cornell Northeast Climate Hub Risk Assessment and Capacity Building Project. Special thanks to Michael Hoffmann, Jonathan Lambert, Joana Chan, Erin Lane, David Hollinger, Richard Stedman, Jennie Cramer, Danielle Eiseman, Jake Pero, and Emma Bankier, among many other colleagues and Cooperative Extension educators, for research assistance and review of this paper.

References

Adger WN (2006) Vulnerability. *Global Environmental Change* **16**, 268–281.

Arbuckle JG, Prokopy LS, Haigh T, Hobbs J, Knoot T, Knutson C, Loy A, Mase AS, McGuire J, Morton LW and Tyndall J (2013) Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. *Climatic Change* **117**(4), 943–950.

Bartels W, Furman CA, Diehl DC, Royce FS, Dourte DR, Ortiz BV, Zierden DF, Irani TA, Fraisse CW and Jones JW (2013) Warming up to climate change: a participatory approach to engaging with agricultural stakeholders in the southeast US. *Regional Environmental Change* **13**(S1), 45–55.

Below TB, Schmid JC and Sieber S (2015) Farmers' knowledge and perception of climatic risks ad options for climate change adaptation: a case study from two Tanzanian villages. *Regional Environmental Change* **15**(7), 1169–1180.

Brugger J and Crimmins M (2015) Designing institutions to support local-level climate change adaptation: insights from a case study of the U.S. Cooperative Extension System. *Weather, Climate, and Society* **7**(1), 18–38.

Chatrchyan A, Erlebacher R, Chaopricha N, Chan J, Tobin D and Allred S (2017) United States agricultural stakeholder views and decisions on climate change. *Wiley Interdisciplinary Reviews: Climate Change* e467.

Corbin J and Strauss A (1990) Grounded theory research: procedures, canons, and evaluative criteria. *Qualitative Sociology* **13**(1), 3–21.

Corbin J and Strauss A (2015) *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. 4th edn. Thousand Oaks, CA: Sage.

Creswell JW (2007) *Qualitative Inquiry & Research Design: Choosing among Five Approached*. 2nd edn. Thousand Oaks, CA: Sage.

Creswell JW (2013) *Qualitative Inquiry & Research Design: Choosing among Five Approaches*. 3rd edn. Thousand Oaks, CA: Sage.

Friese S (2014) *Qualitative data analysis with ATLAS.ti*. Thousand Oaks, CA: Sage.

Haden VR, Niles MT, Lubell M, Perlman J and Jackson LE (2012) Global and local concerns: what attitudes and beliefs motivate farmers to mitigate and adapt to climate change? *PLoS ONE* **7**, e52882.

Horton R, Yohe G, Easterling W, Kates R, Ruth M, Sussman E, Whelchel A, Wolfe D and Lipschultz F (2014) Chapter 16: northeast. *Climate Change Impacts in the United States: The Third National Climate Assessment* 371–395.

Howe PD, Mildenberger M, Marlon JR and Leiserowitz A (2015) Geographic variation in opinions on climate change at state and local levels in the USA. *Nature Climate Change* **5**, 596–603.

Jemison JM Jr, Hall DM, Welcomer S and Haskell J (2014) How to communicate with farmers about climate change: farmers' perceptions and adaptations to increasingly variable weather patterns in Maine (USA). *Journal of Agriculture, Food Systems, and Community Development* **4**(4), 57–70.

Kuehn D, Chase L, Sharkey T and Powers S (2016) Perceptions of maple producers towards climate change. *Northeastern States Research Cooperative:*

https://doi.org/10.1017/S1742170517000710 Published online by Cambridge University Press

SUNY-ESF. http://www.uvm.edu/tourismresearch/publications/maple%20producers%20report%20final.pdf

Kunkel KE, Stevens LE, Stevens SE, Sun L, Janssen E, Wuebbles D, Rennells J, DeGaetano A and Dobson JG (2013) Regional climate trends and scenarios for the U.S. National Climate Assessment: Part 1. Climate of the Northeast U.S. *NOAA Technical Report NESDIS* 142-1, 79 Retrieved from https://www.nesdis.noaa.gov/sites/default/files/asset/document/NOAA_NESDIS_Tech_Report_142-1-Climate_of_the_Northeast_US.pdf.

Liu Z, Smith W.J Jr and Safi AS (2014) Rancher and farmer perceptions of climate change in Nevada, USA. *Climatic Change* **122**(1–2), 313–327.

Maddison D (2007) The perception of and adaptation to climate change in Africa. Policy Research Working Paper 4308. Washington, DC: World Bank. Retrieved from: http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-4308.

Mase AS, Gramig BM and Prokopy LS (2017) Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern U.S. Crop farmers. *Climate Risk Manage* **15**, 8–17.

Mase A and Prokopy LS (2014) Unrealized potential: a review of perceptions and use of weather and climate information in agricultural decision making. *Weather, Climate, and Society* **6**(1), 47–61.

Meyrick J (2006) What is good qualitative research? A first step towards a comprehensive approach to judging rigour/quality. *Journal of Health Psychology* **11**(5), 799–808.

NASS [National Agricultural Statistics Service] (2014) 2012 Census of agriculture: United States summary and state data. *USDA/NASS Rep* 695. Retrieved from: https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_US_State_Level/usv1.pdf.

Niles MT, Brown M and Dynes R (2016) Farmers intended and actual adoption of climate change mitigation and adaptation strategies. *Climatic Change* **135**(2), 277–295.

Patton MQ (2001) *Qualitative Research and Evaluation Methods*. 2nd edn. Thousand Oaks, CA: Sage.

Prokopy LS, Arbuckle JG, Barnes AP, Haden VR, Hogan A, Niles M and Tyndall J (2015) Farmers and climate change: a cross-national comparison of beliefs and risk perceptions in high-income countries. *Environmental Management* **56**(2), 492–504.

Schattman RE, Conner D and Méndez VE (2016) Farmer perceptions of climate change risk and associated on-farm management strategies in Vermont, northeastern United States. *Elementa Science of Anthropocene* **4**, 4–131.

Sietz D, Choque SEM and Lüdeke MK (2012) Typical patterns of smallholder vulnerability to weather extremes with regard to food security in the Peruvian Altiplano. *Regional Environmental Change* **12**(3), 489–505.

Smit B and Wandel J (2006) Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* **16**, 282–292.

Tobin D, Janowiak M, Hollinger D, Skinner RH, Swanston C, Steele R, Radhakrishna R, Chatrchyan A, Hickman D, Bochicchio J, Hall W, Cole M, Hestvik S, Gibson D, Kleinman P, Knight L, Kochian L, Rustad L, Lane E, Niedzielski J and Hlubik P (2015) In Anderson T (ed.) *Northeast and Northern Forests Regional Climate hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies*. United States: Department of Agriculture, p. 65. Retrieved from: http://climatehubs.oce.usda.gov/sites/default/files/Northeast%20Regional%20Hub%20Vulnerability%20Assessment%20Final.pdf.

Tobin D, Radhakrishna R, Chatrchyan A and Allred SB (2017) Addressing climate change impacts on agriculture and natural resources: barriers and priorities for land-grant universities in the northeastern United States. *Weather, Climate and Society* **9**(3), 591–606.

USDA (2016) Adaptation resources for agriculture: responding to climate variability and change in the midwest and northeast. *Technical Bulletin 1944*. In Janowiak M, Dostie D, Wilson M, Kucera M, Skinner RH, Hatfield J, Hollinger D and Swanston C (eds). October. Acessed at: https://www.climatehubs.oce.usda.gov/sites/default/files/adaptation_resources_workbook_ne_mw.pdf.

Walthall C, Hatfield J, Marshall E, Lengnick L, Backlund P, Adkins S, Ainsworth E, Booker F, Blumenthal D and Bunce J (2012) Climate change and agriculture: effects and adaptation. *USDA Tech Bulletin* **1935**, 186.

Weiss RS (1994) *Learning From Strangers: The art and Method of Qualitative Interview Studies*. New York: Simon and Schuster.

Wolfe DW, Comstock J, Lakso A, Chase L, Fry W, Petzoldt C, Leichenko R and Vancura P (2011) Agriculture. In Rosenzweig WSC, DeGaetano A, O'Grady M, Hassol S and Grabhorn P (eds). *Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State [Technical Report]*. New York State Energy Research and Development Authority (NYERSDA). Retrieved from: https://www.nyserda.ny.gov/climaid.

Appendix 1: Interview Guide

Focus Group Interview Questions (following introduction, background, overview of forms, respect for all voices to be heard and confidentiality statements):

Let's start by going around and having everyone quickly share three things about yourself: your name, what type of farming you practice and where your farm is located.

(1) (New York/Pennsylvania) has experienced a number of unusual weather events or changes over the past 10 yr, such as extreme rainfall or short-term drought, heat waves, changes in the growing season and increases in pest and disease pressure. As a farmer, have you experienced any impacts or events similar to these? If so, what were they?
   a. Briefly tell us about a memorable event or impact you recall. How did this affect your farm?

(2) Have you made any changes to your farm operation (such as changes to your farming practice or infrastructure as a result of the events or impacts we just talked about?
   a. Sometimes farmers make such changes to their operation or practices because it reduces risk, makes economic sense or is good for the environment. What were your main motivations for making those changes?
   b. Do you feel that you are well prepared for similar events in the future? Why or why not?

(3) What do you feel are the most significant risks to your operation now, and over the next 5 yr? How do weather and climate concerns compare or fit in with these risks?
   a. What do you feel are the most significant risks to your operation related to extreme weather and climate variability?
   b. We talked about steps some of you may have already taken to reduce your risk in a previous question. What steps do you plan to take, or would you like to take, to reduce these risks in the future? What are the main obstacles to you making these changes on your farm or in your practices?

(4) How well prepared do you feel to handle any future climate risks?
   a. How do you think your preparedness compares to your neighboring farms or peers?
   b. Are there any changes your peers have put in place that you would like to adopt?
   c. How do you learn about the practices your peers are putting in place, and does that affect your decisions?

(5) When looking at the next 5–10 yr, what type of information, tools or training do you need to help you respond to increasing climate risks on your farm?

(6) Where do you currently get the information that helps inform your decisions about extreme weather and climate change?
   a. Family or peers?
   b. University researchers, cooperative extension, federal agencies, state agencies, farm advocates (i.e., Farm Bureau, others)?

(7) Most scientists believe that human activities are causing the rapid changes to the Earth's climate we are observing. What role, if any, do you believe agriculture has in reducing the impact on the climate?
   a. Have you made any changes to increase the energy efficiency of the farm or use renewable energy (solar, wind or biogas)?
   b. Have you conducted an energy audit on the farm, or do you plan to conduct one?
   c. Have you put in place conservation practices or manure management practices that also help reduce your farms' carbon footprint?

(8) As we prepare to conclude this session, is there anything else that you feel is important related to climate impacts and responses?

Thank you very much for participating in the focus group session today. Your time is very much appreciated and your comments have been very helpful.

https://doi.org/10.1017/S1742170517000710 Published online by Cambridge University Press