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# Climate Change and Dairy in New York and Wisconsin: Risk Perceptions, Vulnerability, and Adaptation among Farmers and Advisors

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**Abstract:** Climate change impacts on agriculture have been intensifying in the Northeastern and Midwestern United States. Few empirical studies have considered how dairy farmers and/or their advisors are interpreting and responding to climate impacts, risks, and opportunities in these regions. This study investigates dairy farmer and advisor views and decisions related to climate change using data from seven farmer and advisor focus groups conducted in New York and Wisconsin. The study examined how farmers and advisors perceived climate impacts on dairy farms, the practices they are adopting, and how perceived risks and vulnerability affect farmers' decision making related to adaptation strategies. Although dairy farmers articulated concern regarding climate impacts, other business pressures, such as profitability, market conditions, government regulations, and labor availability were often more critical issues that affected their decision making. Personal experience with extreme weather and seasonal changes 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 dairy in the Northeast and the Midwest US.

**Keywords:** climate change; resiliency; impacts; dairy; farmers; advisors; perceptions; vulnerability; adaptation

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## 1. Introduction

### 1.1. Perceptions of Climate Change and Adaptation Strategies

Although the biophysical sciences have been predicting the impacts of climate change on agriculture in the US, far less attention has been dedicated to understanding dairy farmer and advisor perceptions and responses to extreme weather and climate change. Researchers have long recognized that the simple transfer of knowledge is generally insufficient to accomplish sustainable behavior changes [1–3]. Studies regarding the adoption of new, innovative ideas, practices, and technologies related to agricultural conservation [4,5] and climate change [6–8] reinforce the importance of understanding the factors that motivate and/or prevent actors from adapting to and mitigating change. In addition, this literature suggests that messages and interventions should be crafted in ways that address these motivations and barriers.

Several studies have concluded that the climate change information generated by scientists must be made relevant to local contexts for farmers to find it useful [9–14]. Some [15] highlight the importance of taking farmer perspectives into account; they document how personal experiences with climate-related events inform risk perceptions and help determine adaptation actions among Vermont farmers. Others [16] found that those farmers who accept anthropogenic climate change are more amenable to adaptive and mitigative action than those farmers who do not accept human causation of climate change.

Vulnerability is another key concept to consider in order to understand farmer perceptions and actions related to climate change [15]. Vulnerability includes exposure, sensitivity, and adaptive capacity [17]. Exposure refers to the kind and intensity of impacts to which a system is subjected; sensitivity is the degree to which these impacts affect the system; and adaptive capacity represents the potential for the system to maintain resilience when confronting climate stresses [18,19]. Vulnerability in a particular situation is determined by both biophysical and social processes [20].

Perceptions of risk associated with climate change are also important to consider because actions are predicated on farmers' understandings of the threats that exist. Some researchers [16,21,22] argue that considering farmers' perceptions of climate change is important to understanding their willingness to adopt adaptation or mitigation strategies. Likewise, others [9,15] conclude that the perception of climate change as a risk is an important factor that precedes adaptive or mitigation action.

Adaptation can be defined 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" [23] (p. 60). Adaptations can be seen as evidence of adaptive capacity and therefore vary depending on the specific vulnerability context [17]. Adaptation practices can be anticipatory or reactive, and they are overt responses to perceived threats. Mitigation refers to the reduction of greenhouse gas (GHG) emissions driving climate change by reducing GHG sources and increasing their sinks [23].

Most studies find that farmers are more likely to adopt adaptation practices behavior than mitigation practices, because many farmers are still skeptical of anthropogenic causes of climate change and do not believe that they are causing climate change or that the changes they would make to reduce GHG emissions will have any positive effect on their farm [6,16,24]. Climate adaptation practices often more easily fit into existing farm management practices because they are changes that can be made locally and immediately, so the effects can be seen in the short term; whereas mitigation practices such as reducing greenhouse gases may tend to focus affect-creating changes on larger spatial and time scales.

This study contributes to understanding dairy producers' perceptions and actions to address climate change by analyzing dairy stakeholder views in Wisconsin (WI) and New York (NY) about extreme weather and climate change impacts, their management responses, and their underlying rationales for action. The remainder of the paper will elucidate the results, followed by a discussion and a brief conclusion. The climate change risk perceptions of dairy farmers and advisors who participated in the focus groups herein are similar to perceptions from other kinds of farmers in the Midwest and the Northeast insofar as vulnerability and risk are key factors underlying farmers' willingness to adopt adaptation and mitigation practices [15,16,22]. This expands upon a conceptual and empirical link established between climate change beliefs, risk perceptions, and adaptive action among Midwestern farmers [22]. Our study examines how climate change risk perceptions, and to some extent beliefs, relate to dairy management practices to better understand the outlook for dairy in the changing climate.

### *1.2. Impacts of Climate Change on US Dairy*

Wisconsin and New York are the number two and three dairy-producing states in the US, respectively, generating slightly over half of the United States' milk production by weight in 2017 [25]. Both states have similar temperate climates: warm, humid summers, and cold, snowy winters. The growing season usually comes with ample precipitation for crop and forage growth. Climate

patterns in Wisconsin and New York have changed over the past 60 years, including a 1.4–3 °F increase in winter temperatures, earlier last-frost dates in the spring, later first-frost dates in the fall, less snow and more rain in the winter, and increased frequency of intense precipitation [26,27] (Table 1). These trends are already affecting the agricultural sector and dairy production systems and are expected to continue given the projections for climate change [28–30].

**Table 1.** Recent historical trends and mid-century projections for the Wisconsin (WI) and New York (NY) climate.

x	Historical Data 1950–2006 for WI 1970–2008 for NY2	Climate Change Projections 2050 (WI)1 2055 (NY)2
Temperature	<ul style="list-style-type: none"> <li>Increased 1.1–2.5 °F statewide in WI and 2.32°F in NY, with the greatest warming in the winter</li> <li>Growing season has increased 12 days on average (WI)</li> <li>Last frost comes earlier, and first frost comes later</li> </ul>	<ul style="list-style-type: none"> <li>Likely to be 4–9 °F warmer overall in WI and 3.0–5.5 °F warmer overall in NY</li> <li>Growing season projected to increase by 4 weeks</li> <li>Milder winters</li> <li>Heat waves are very likely to become more frequent, intense, and longer in duration</li> </ul>
Precipitation	<ul style="list-style-type: none"> <li>Increased an average of 10% statewide in WI with greatest increases in winter and autumn. No significant differences in NY</li> <li>Intense precipitation has increased in both frequency and magnitude</li> </ul>	<ul style="list-style-type: none"> <li>Either too much or too little water overall in WI, with extreme events in spring and fall</li> <li>More rain than snow in winter</li> <li>Thermal heat index (temp and humidity) expected to increase in summer</li> </ul>

Note: 1 [26]; 2 [27]. Trends do not include data for New York City.

Changes in the rainfall patterns could have serious, detrimental impacts on dairy systems. Increased precipitation in the spring can delay planting and harvesting, cause soil erosion and loss of fertility, increase soil compaction from heavy machinery, and reduce yields. Increased drought can affect crop yields, create erosion risk, and cause feed shortages.

Animal comfort and health may also be affected. Increased temperature and humidity can stress cows and reduce reproduction rates and milk yields due to decreased food intake [29–31]. Milk production is less likely to be dramatically impacted in the northeastern and midwestern states than it is in western states (where a growing proportion of the country’s milk production is occurring and where it is expected to increase) [32]. Dairy production systems in the Northeast and Midwest have multiple adaptation strategies available to adjust to climate change, such as changing crop varieties, adjusting planting dates, or improving cooling capacity of dairy barns [33]. Thus, proactive adaptation has the potential to provide these farmers with a competitive advantage over other areas of the country.

These new climate change pressures are developing during a time of change in the dairy industry. Farm sizes and milk yields have increased significantly in the recent past, while the total number of farm operations and milk prices have declined. For example, Wisconsin experienced a 50 percent decrease in the number of milk cow herds from 2004–2019 [34], with a two percent increase in the number of cows [35], yet milk production rose about 28.7 percent from 2006–2016 [36]. According to the USDA’s Census of Agriculture, between 2007 and 2017, the number of dairy farms decreased by 38 percent in Wisconsin, and in 2018 alone, Wisconsin lost 638 dairy farms [37,38]. That is a 7.25 percent decline in the number of registered dairy herds—the biggest drop since records started in 2004. The decline is likely influenced by retirements and consolidation within the industry [38]. In New York State, many smaller farms, facing financial hardship or run by aging owners, are closing at a rate of over 100 per year. According to the USDA Census of Agriculture, the number of dairy farms decreased by about 31 percent from 2007–2017, but the number of milk cows decreased by less than 1 percent in that same time period [39,40], and the total milk production increased by 23 percent [41]. In fact, milk production has risen steadily in recent years. Consolidation in the dairy industry is resulting in larger farms with more cows, and cows are becoming more productive. Nationally, there was a 13 percent increase in milk produced per cow from 2009–2018 [42]. However, these larger farms along with the more highly productive cows may be more vulnerable to extreme weather and climate change. For example, the larger, more productive cows are more vulnerable to chronic heat stress due to their high metabolic rate [27,28,30]. Furthermore, on these large farms, typically corn, soybeans, and silage

are grown on the fields, and formulaic rations are brought into the barn to the cows, so the effects of climate change such as drought and increased extreme rainfall on these feed crops are critically important to the modern dairy systems in both New York and Wisconsin. Additionally, with prices depressed, farmers who are looking to sell are having a hard time finding buyers. Some farmers have increased their revenue by producing organic milk, which they can sell at \$43 per 100 pounds, or hundredweight [43]. This higher organic milk price is sometimes three times the going price for conventional milk, which has dropped below \$15 per hundredweight from its peak of over \$25 in 2014 [43]. It should be noted that milk prices are calculated under federal guidelines and have been decreasing through a combination of strong milk production (supply) and weak demand in both global and domestic markets. The changes in demand in international markets is often related to global trade politics, and the domestic demand has been decreasing because Americans turning to alternatives such as soy and almond drinks [43]. Both the climate and the dairy industry appear to be changing, and their interaction may multiply the risks posed by the market trends.

## 2. Materials and Methods

This study assesses dairy farmers' perspectives of climate change through seven farmer and advisor focus groups (see Table 2) conducted in NY and WI, two of the leading dairy-producing states in the United States. The strategy for the focus groups focused on expert opinions of producers and their advisors working in the dairy industry, following established methods [44]. Focus groups were open to any dairy producer or advisor in the specific county or region of interest (see Table 2 below). The farmers were generally those who bred, raised, and milked cows and also grew much of their own feed on the acreage they owned. The advisors included agronomists and crop consultants—private agents—who advise farmers about nutrient and manure management, what kinds of crops to plant that year, how much of each type to plant and recommend when to plant. Other advisors were Extension agents who work at the county level and interact with farmers on a regular basis but are University employees. In addition, the focus groups contained both male and female advisors and farmers.

**Table 2.** Focus groups conducted in New York and Wisconsin in 2016 and 2017.

Focus Group	Location	Date	Target Participants	Number of Participants
St. Lawrence County, Canton, NY	CCE Office, Canton, NY	28 June 2016	Dairy Producers	5 farmers
Cayuga County, Auburn, NY *	CCE Office, Auburn, NY	14 August 2017	Dairy Advisors/Producers	2 dairy crop and livestock advisors; 1 dairy/livestock farmer; 1 field crops/livestock farmer; 2 livestock farmers; Total = 6
Madison County, Morrisville, NY	CCE Office, Morrisville, NY	1 January 2017	Dairy Producers	6 dairy farmers; 1 livestock farmer Total = 6
Cortland County, Cortland, NY	NYS Grange Office, Cortland, NY	30 August 2017	Dairy Advisors	9 Advisors
Madison/Dane County, WI	Wisconsin Agri-Business Conference, Madison, WI	11 January 2017	Dairy Advisors	8 crop and livestock advisors
Madison/Dane County, WI	PDPW Conference, Madison, WI	15 March 2017	Dairy producers	3 Wisconsin dairy farmers
River Falls/St. Croix County, WI	PDPW board meeting, River Falls, WI	23 June 2017	Dairy producers/leaders	9 farmers (PDPW board members); 1 banker, 1 PDPW staff member Total = 11

\* Data included from this focus group is limited because it predominately featured livestock producers with two dairy advisors present; dairy relevant information was retained for this analysis.

Recruitment of focus group participants for each session was conducted by emailing existing lists of farmers, using a google form RSVP, placing meeting notices in agricultural newspapers, and coordinating with Extension specialists and industry leaders who have existing relationships with

producers and advisors. In NY, the researchers offered an incentive for participation in the focus groups of a raffle for a \$50 Tractor Supply Gift Card selected by a raffle of all farmer/advisor names at the end of the group session. In WI, participants were offered \$25 gas cards as an incentive.

A team of researchers conducted three focus groups in each state using semi-structured focus group interview guides. In total, there were 40 participants. Table 2 provides an overview of the focus group participants. The focus group interview guide (see Appendix A) was developed by the authors of this study and reviewed by a panel of researchers with technical expertise in dairy production and qualitative research methods.

The focus groups, conducted between June 2016 and November 2017, lasted approximately 60–75 minutes each and were audio recorded and transcribed for analysis. An a priori coding framework of key themes from the literature on farmer views and actions related to climate change impacts [15,16,22,45] was developed to guide the coding process (see Appendix B). 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 Dedoose software an online application for analyzing qualitative and mixed methods research data. We employed an axial coding procedure (to identify relationships and connections among the codes) and to examine key concepts and themes that emerged from the participants in each group [46,47]. To represent the themes conveyed by farmers and advisors, particularly compelling direct quotations were selected for analysis [48].

To perform the analysis, there was an intercoder agreement, in which two coders coded and analyzed each focus group transcript separately without seeing the other's coding until the coding was finished. After coding was complete, the two coders inspected similarities and differences to discern themes and to ensure consistency in interpretation [49,50]. Because of the large number of emergent codes produced by both coders, and because of the large total number of codes, an inter-coder (inter-rater) reliability test was not suitable to measure the intercoder reliability. The statistics would have indicated divergence where there actually was none because different emergent codes were assigned different names but had consistent thematic meaning. Furthermore, Dedoose does not have a built-in inter-rater reliability calculator. Therefore, in lieu of an inter-coder reliability test, the two coders visually inspected each focus group transcript with both coders' completed codes present and visually inspected for thematic divergences. Next, they had thorough discussions via Zoom and phone with notes taken to document the process. Through this inter-coder dialogue, the coders agreed that the themes were consistent in meaning despite differing names for emergent codes. This inter-coder agreement helped validate the analysis [49,50]. The final codes from the two coders did not result in substantially different codes (in terms of meaning), and any differences were easily reconciled for the final thematic analysis.

Given the small sample size of qualitative focus group research studies like this one, the findings need to be interpreted with care. As a qualitative study, the intent was not to generalize but to provide rich description, particulars, and specifics from the participants [49]. Another potential limitation may be with potential bias in the farmers that participated in the focus groups. Although the researchers strived to invite a diverse group of farmers to participate, the farmers that chose to participate were those who were in close connection and existing relationships with Extension (in New York) or who were participants in large producer meetings (in WI). Future qualitative studies exploring similar themes would benefit from expanded sample sizes to diversify and saturate perspectives and ensure that the voices of demographic sub-categories (race, gender, etc.) are considered [50].

### 3. Results

#### 3.1. Observed Climate Change Impacts on the Dairy Farm

Farmers participating in both the NY and WI focus groups reported an increase in extreme weather events on their farms in recent years and changes in the climate over the years they have been farming. Dairy farmers and advisors in both NY and WI reported more frequent extreme precipitation events and

consequent shortened windows of time to work the fields (hereafter “shortened windows”). Shortened windows refer to the reduced amount of time in which the fields were dry enough to get in and plant, harvest, or do any practice that necessitates heavy machinery. This has led to both late plantings and late harvests. Participants of all six groups reported having experienced extreme precipitation leading to erosion, runoff, deposition, flooding, and wet fields, as well as drought and decreased precipitation, and all expressed concern about the effects of both too much and too little water.

As an example of the shortened windows concerns, one WI farmer noted how recent weather had affected his ability to spread manure within the regulatory guidelines of Wisconsin:

*... one concern is ... about Wisconsin rules, ... I think if you're a certain size farm, there's a calendar date that you have to meet to apply manure, and given this crazy weather, in some years, maybe some of the best time to haul manure is when the calendar says you can't. And so if you're trying to match extreme weather events with policy that's based on an arbitrary date, that's frustrating when the policy closes the window too (WI Farmer).*

One NY focus group also expressed concern about increased erosion caused by extreme rains combined with the fact that some farmers had cut down trees and hedgerows between the fields. According to an advisor in Cortland, NY, the field sizes in his region are relatively small, so farmers often cut down trees between fields to increase their tillable acreage and facilitate manure spreading with draglines:

*I think your average field size is under 20 acres ... and that's a negative to me because what the doing is they're ripping out ... hedgerows to make them bigger ... now we're losing soil from these extreme weather events, and it's just washing down the longer slopes that we have and no longer have hedgerows between (NY Advisor).*

Flooding and heavy rain is a significant concern to farmers. A WI farmer discussed a recent event near his property:

*... probably the biggest thing is we live in the hills, and water likes to run downhill, so last August we were in that major flood where it took out a bunch of roads ... ; But it probably wasn't so much that that caused us tremendous problems; when you have to figure out how to get a milk truck in, because so many roads are washed out, that's not fun. But then it wasn't but two weeks later when they started getting things up and running again that we got another 5 inches. And it was fast. It seems like we no longer get mediocre rains. We either get a bunch, or nothing. This year the same thing (WI Farmer).*

Droughts and dry periods between rainfall events are also a concern, but some of the participants state that modern hybrid seed varieties and technology such as drought and rot resistant hybrids have alleviated some of the risk. One advisor from Wisconsin noted the drought of 2012, while similarly severe to one which occurred in 1988, caused significantly fewer losses due to new, more drought tolerant hybrids.

*2012 was close; 2005 was bad for us, but even then ... (With) the modern-day varieties, hybrids we have, it's gotta be pretty severe. They can hang in there and hang in there, and finally it rains. And it comes around like you wouldn't believe (WI Advisor).*

Decreased snowfall has also had impacts. One WI farmer noted the change in snowfall as follows:

*I've even noticed that ... we've had a lot less snowfall, and so we've had a lot less covering over the winter and having to deal with winter kill and things like that, and the amount of liquid that's going into your pit from the snow has dramatically changed (WI Farmer).*

Less snow cover leads to less insulation of the soil and plant growth underneath, which affects the winter kill of cover crops, and when the ground will be ready to work. If there is not sufficient freezing to kill cover crops, then herbicides may be used instead. If the soil freezes deeper because of the lack of snow insulation, the fields could stay frozen longer, which could affect planting times. Also,

with less snow, there is less water during snowmelt that goes into the manure storage pit. In sum, these dairy farmers and advisors report having observed changes to weather patterns over the past few decades, and that these changes have had serious impacts on their farm operations.

### 3.2. Management Practices and Decision Making

When asked about adaptation practices that they were implementing to respond to the perceived climate impacts, dairy farmers and advisors in NY and WI stated that they were already employing resilience practices such as reduced till or no-till, installing tile drainage, which is a subterranean drainage system to get water off the fields so the fields can be worked, cover cropping, purchasing different equipment, shifting planting times, putting a ‘retainer’ on manure spreaders and other machinery operators, and new manure handling techniques. These practices (summarized in Table 3) were often adopted in response to perceptions of shortened windows, soil erosion, and water quantity and quality issues in addition to changing soil and water conservation.

**Table 3.** Management actions discussed by dairy farmer and advisors in NY and WI.

Adaptation Types	Examples
Practices	<ul style="list-style-type: none"> <li>✓ no-till</li> <li>✓ cover crops</li> <li>✓ changing planting times</li> <li>✓ planting new plant breeds and varieties</li> <li>✓ manure handling–draglining and injecting</li> </ul>
Equipment	<ul style="list-style-type: none"> <li>✓ larger tractors</li> <li>✓ bigger equipment (e.g., larger hay balers-from square to larger round bales)</li> <li>✓ smaller tractors (NY only)</li> <li>✓ 4-wheel drive tractors (NY only)</li> <li>✓ precision ag equipment</li> <li>✓ more manure hauling equipment</li> <li>✓ putting a ‘retainer’ on equipment operators</li> </ul>
Infrastructure	<ul style="list-style-type: none"> <li>✓ climate controlled barns</li> <li>✓ robotics in milk parlors</li> <li>✓ paddocks for rotational grazing</li> <li>✓ tile drainage</li> </ul>

One WI dairy adviser suggested that a shift towards no-till allows farmers to get out into the fields sooner after heavy rainfall events:

*... with the weather events, the heavy rainfall, ... with their no-till ground, you can get on the ground way quicker than if you have tilled ground ... when silage comes off, they recognize the importance of getting rye on it, with every farmer I work with it's automatic: winter rye goes on it as quick as they can (WI Advisor).*

The importance of getting out onto the field as quickly as possible to adapt to the shortened windows was a common motivator for the adoption of both larger and smaller machinery and 4-wheel drive tractors.

*We sold our equipment, and then hired in bigger equipment. ... more or less just for forage quality, but it all comes back to the window. The window's only so big (WI Farmer).*

Working fields during these shorter windows can cause soil compaction and damage, which decreases soil health. One WI farmer was very concerned about the consequences of this trend:

*One of my concerns is that, when the window shortened up, we're pushing it ... I know that we're doing more subsoil structure damage ... when the corn silage is ready the corn silage is ready. ... instead of using*

trucks, we were using dump carts with the big tractors to basically mud it out, and that damage had to be fixed (WI Farmer).

Some manure haulers have purchased more equipment to spread manure faster when the opportunity to spread exists. A NY adviser highlighted this trend:

*... talking to our manure haulers, they've invested in more equipment because their windows are getting so much shorter, everybody needs it right now, so those guys, they can't be everywhere at once. And as farms grow that's usually something that's custom done, so those guys are really having problems with shorter windows, trying to get everybody taken care of, and it's just really tough (NY Advisor).*

While many farmers purchased larger equipment to get more done in less time, some are buying smaller, lighter equipment to reduce soil compaction:

*And our equipment is smaller and lighter so we can go in on one fields and not cause compaction issues ... because we aren't running the heavy equipment we can go in and we can get on grounds maybe a little bit wetter ... (NY Farmer).*

A Cortland, NY advisor talked about how farmers have had to switch to 4-wheel drive tractors due to the need to spread manure in almost all the weather conditions:

*... let's face it; pretty much every farm has a 4-wheel drive tractor nowadays. That didn't use to be a regularity ... the smaller farms got by without them. They stockpiled manure if they needed to ... and now they don't do that. They know from an environmental perspective, and for a lot of reasons, that they've got to be able to get up there and spread every day, even in bad weather ... so ... we've seen everybody's got a 4-wheel drive tractor (NY Advisor).*

Farmers often frame these adaptations around farm profitability, rather than ecological or resilience concerns; as exemplified by the following quote from a NY farmer discussing his decision to install tile drainage:

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

A NY Adviser stated that economic reasons motivated the decision to plan Triticale more than resiliency—even though planting Triticale as a cover crop can have both economic and environmental benefits:

*You understand though that then there's that economic connection too because Triticale keeps their options open. They can take it off again in the spring and have some extra forage (NY Farmer).*

Dairy farmers and advisors in both NY and WI were concerned with the ongoing viability of their operations. One NY farmer asked why he should care about ten years from now if he is going to be out of business in five. Many farmers see adaptation as a fundamental part of a successful farming operation:

*I would say that we've always kind of adapted ... I think we're managing everything tighter, be it grid sampling, to accurate nutrient management, to seed placement (WI Farmer).*

An advisor from NY summarized the reasons for adaptations as follows:

*I think ... (the reasons for adaptations) are linked between the stewardship and the economic ... On the field crop side, soil loss, a visual soil loss, making farms go back to putting in more strips or making sure that their grass waterways are kept in place and being more conscientious about giving instructions about not plowing those up when they're plowing up fields, not spraying. Cover cropping, dedicating personnel to be a cover cropper as they're taking corn off. We never saw that on farms before. They've dedicated equipment and a person to that event (NY Advisor).*

Manure handling and herbicide use have also been changing in response to extreme weather changes. A Wisconsin advisor noted that manure application rates have been declining due to better nutrient management, regulatory restrictions, and the weather:

*Manure application rates, it's been interesting to watch that, particularly in the Northeast with our heavy clays, where 30 years ago it was not uncommon to put on 30, 40, 50,000 gallon application rates ... now those application rates continue to drop dramatically, and part of it's from nutrient management, pressure, and regulatory issues, but I think a lot more of it is reaction to weather; like you guys said going at lower rates and spreading it out in more multiple locations, and I've probably got some form of slow release nitrogen going on almost every acre now, I would have never did 3-4 years ago; that is taking off along with cover crops and things like you guys talked about (WI Advisor).*

The same advisor noted how precipitation changes have caused some farmers to shift from post-emergent to pre-emergent weed killers/herbicides:

*But also even herbicide applications have changed ... we've shifted way back into the pre (emergent), so they've got that protection on there, they just cannot chance ... after rains and worry about trying to get that post-emergent application on, so they've done more pre's, so that's been a definite shift, I think it's been because of the weather a lot of it ... (WI Advisor).*

In sum, farmers are adopting practices that are part of the toolbox of climate change adaptation practices—even though they may be adopting them to address issues of stewardship, compliance with regulations, economics, and extreme weather, rather than simply responding to climate change impacts.

### 3.3. Climate Change Beliefs

While none of the dairy farmers in NY and WI expressed anti-climate science views, many were uncertain of the drivers of change, or whether the changes are relevant to their operations. Dealing with climate variability is, after all, “just farming”:

*They're used to dealing with Mother Nature so this to some degree ... isn't ... different than it's always been ... every day their whole life, their whole career ... they're used to just being at the whim of the weather ... (WI Advisor).*

One NY advisor spoke of the resilience of dairy farmers:

*... they're the greatest ... survivalists out there ... because ... they have to survive, they have to adapt, they have to ... be resilient.*

Another farmer shared similar sentiments regarding how farmers have to “evolve” with the changes in the environment: “I think as the climate and environment evolve, we have to evolve with it.” Many farmers expressed little interest in establishing the causes of climate change, instead saying that they'll do what's right for their farm:

*I think that we are seeing changes; whether it's our fault, I'll leave that up to God, but it makes economic sense to keep carbon in the soil where it belongs; it really does, that's where a lot of our money comes from ... (NY Farmer).*

Some farmers did express their firm belief in the anthropogenic causes of climate change, however:

*I personally believe in the past 100 years burning all these fossil fuels, and 95% of the scientists believe that we're having an effect. And I believe that we are (WI Farmer).*

### 3.4. Climatic and Non-Climatic Risk Perceptions

To understand how dairy farmers and their advisors were prioritizing climate change in their decision making, the participants were asked to reflect on what they perceived as the primary risks to their operations or others with which they are familiar. Participants identified risks and concerns about

climatic and non-climatic issues. The climatic risks—especially increased extreme weather—were intertwined with and tended to have an amplifying and multiplying effect on the non-climatic risks such as regulation, threats to profitability, and a shortage of high-quality labor. Of the non-climatic risks, regulatory risks emerged in all six groups, profitability risks were discussed in five out of six groups, and labor risks came up in four out of six groups. Farmers and advisors expressed the importance of minimizing and managing risks. One Wisconsin advisor referred to both advisors and farmers as “risk reducers:”

*I think we're hired as risk-reducers. I think farmers are trying to be risk reducers too ... (WI Advisor).*

All of the groups consistently highlighted regulation as a concern. As one advisor in Wisconsin noted:

*... regulatory risk is just unbelievable ... . What we've got currently is bearable ... We certainly help our clientele comply with regulatory issues, but it just looks like what's coming down the road is just unbelievable. So, how that's going to be addressed, it's hard to tell (WI Farmer).*

Farmers expressed frustration over how the written regulations were inconsistently interpreted by regulators. Two WI farmers expressed exasperation over this inconsistency:

*We have a huge amount of clients that have complied with the DNR regs [Department of Natural Resource regulations], put in manure pits, put in grass water strips, spent 30 to 50,000 dollars on consultants because nobody else pays for that anymore; and now have to redo that 2 years later when it was just done in '14 to '15. Now the new DNR guys come out with 4 people and say you've got to redo this all ... I've never seen so much frustration in that environment in my life ... (WI Farmer).*

Regulatory requirements are usually associated with Concentrated Animal Feeding Operations (CAFOs), and they can impose significant restraints on farmers' day-to-day operations and come with additional management and record-keeping obligations. One farmer in Wisconsin described the difficulty of balancing the needs of his operation with the requirements of environmental regulations:

*... with the DNR regulations wanting to say, well, you can't do this within so many hours of a such-and-such rain. Well, you don't know it's going to be a 1-inch rain, and you go out and spread anyway ... it gets really hard to manage that sort of activity. They want everything so they can write it down on a piece of paper to know that you followed the rules exactly, and you just can't do it (WI Farmer).*

Market volatility was also a common concern. Climate impacts such as the drought of 2012 made feed and forage more expensive due to increased scarcity in a dry season, changing how some farmers manage their feed inventory:

*... 2012 probably changed how people manage their inventories; you're never going to be short on feed ever again ... because if I don't have that feed then I can't feed my cows, and buying it's really tough. So everybody just grew more inventory (WI Farmer).*

Price volatility in the conventional milk market was perceived as a significant risk. One NY farmer emphasized that as global markets for US-produced milk products expand, prices are increasingly impacted by global trade:

*... in dairy we export more and more of our product and ... if you ... lose the export markets, then it's all flooded back on the domestic (market); it becomes a profitability problem because milk prices tank, so... you certainly want to continue to have dairy products flowing out of the United States ... rather than all stuck here (NY Farmer).*

Another summarized the influence of exports with some statistics:

*In the last 20 years, we've gone from like 3.5%... to a high of 17% exports, and we're back down to 14%, which was enough ... to crash (the market for dairy) ... (NY Farmer).*

These factors, along with the stress of extreme weather events, increase the stress on dairy producers in both states. Another commonly voiced concern was the scarcity of qualified labor. This issue was raised in four out of the six groups; one Wisconsin farmer said that the concern for labor keeps him up at night:

*... labor, it's always a concern; you know it's a pretty labor-intensive deal we're in, that keeps me up sometimes. (WI Farmer)*

One NY farmer described how labor is sometimes in short supply because the demand for haymaking and spreading manure happens for many farmers at once—often during a shortened window when the weather will cooperate:

*Because I mean we ran into this; I think the three of us have all called the custom guy the same day. When everybody cuts their hay about the same time and everybody wants to spread [manure] about the same time and that's that so you pass the custom guy, you don't get to the farm (NY Farmer).*

Sometimes, the shortage of labor is exacerbated by the shortened windows mentioned above, so farmers have been changing practices to get as much done with the available labor in the shortest time possible. Some farmers are changing crop rotations away from hay to better cope with these shortened windows and the scarce labor supply:

*... there's been a lot of changes ... Larger farms have been way ahead on these sort of things because labor is difficult and so when you have wet conditions or conditions that are ... unusual they need to make the most of the time that they have ... anything from small square bales to larger round bales to large square bales to putting up more haylage than dry ... They've gone to growing wheat as a source of a cover crop seed, and ... the straw that comes off the wheat now becomes a supplement to nutrition like the dry hay was but ... also used for bedding, and ... there's been a definite transition in the cropping rotation. We never grew as many soybeans. We never grew as much wheat ... all those acreages came out of what was dry hay at one time (NY Farmer).*

Although farmers extensively commented on the importance of non-climatic risks, they considered multiple risks simultaneously, including climate change. One farmer noted that decision making needed to address climatic threats, public perceptions, and regulations all at once. Thus, despite the fact that the climate risks were often subsumed under profitability risks, many of the farmers noted that climate risks, especially vulnerability to extreme weather events, were factors in their decision making.

Farmers are also concerned about their relationships with the non-farming public, as they face increasing consumer choice pressure, scrutiny of their conservation practices, and a growing number of non-farming suburban neighbors. Concerns regarding consumer pressures were expressed by five out of six focus groups. A WI farmer described the financial and environmental effects of consumer choice pressure related to recombinant bovine somatotropin (rbST) and genetically modified (GMO) crops:

*I think one of the big things that's moving forward now is the disconnect between the consumers and the farmers, so you know we have rbST which is if we're going to talk about sustainability, talk about saving the planet, things like that, probably one of the best, most well-researched products in the history of the world, that we're not going to be able to use anymore; the effect of that is that people are going to milk more cows, gonna have more manure, gonna use more water, gonna use more feed, all those different things, because your income took a 10% hit, and you don't just replace that; now we're looking at GMO crops being a negative thing, and again, if I have to go across my field once, maybe twice, because I no-till plant, and I spray it once, and harvest it once, that's three trips across the field, but if we have to not be able to use some of the technologies we have, and we have to cultivate and we have to do different things, we're using more fossil fuels and so, the disconnect between the consumers asking for something and the true benefit that they're really getting... (WI Farmer).*

Farmers also expressed a strong sense that dairy and agriculture in general suffers from a negative public image, even though they are environmental stewards:

*I think we need to be very careful because when you talk with the general community and you say agriculture, they think all of agriculture. We don't have a lot of feedlots in New York State. We have a lot of dairies that are actually carbon negative and so that message is not getting involved. I live in a very liberal community who got enticed by this Albany/New York State Go Vegan Lunch Program, and I had to end up writing a huge letter writing campaign because they were turning all the kids in our district against agriculture because they are so, are contributing so much to the global issue of global warming and that's not the case with our dairy farmers (NY Farmer).*

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. Participants were concerned about additional risks arising from growing anti-agriculture sentiments, and that constraints were being imposed on their operations by people with little understanding of the realities of the dairy business.

### 3.5. Sources of Information

Farmers reference a variety of information sources that inform their decisions [51]. One WI Advisor described farmers as willing to use any source of information necessary to reduce risk, including their own experience:

*... they're looking at any source of information they can get a hold of, whether it be Climate Corp, or NOAA, or wherever else. You know a lot of those guys, they've been farming for 20, 30, 40, 50 years, so they've kind of got a handle on it too ... they can predict the weather better than the weatherman... (WI Advisor).*

But not all information sources are viewed equally. Most influential are generally peers, family, farm advisors, farming neighbors, marketers, internet sites (weather and farming groups) and University Extension. Farming peers are a primary source:

*I think we all feel about the same, it's just we have to be willing to adapt and do different things and look at how our neighbors do it. I'm going to look [at] what they're doing ... to see what they're doing and ... say "hey look that field looks great, what'd you do there? ... and that field looks terrible. Mind telling me what you did wrong? (WI Farmer).*

Farmers also receive information from salespeople and industry. However, this information may be seen as less trustworthy. A NY farmer spoke of the paradoxical need for, and skepticism of, information coming from salespeople:

*But generally, you learn from the people that ... (information) actually comes down retail channels, which is always a pain because you don't know whether to trust them ... but they're the ones that show up at the door ... (NY Farmer).*

This simultaneous dependence on salespeople and slight distrust of their impartiality was also expressed by a WI advisor:

*Part of its technology, because in our area we've got a couple dealers that have really pushed that idea of side dressing dry fertilizers; they've invested in the equipment to get that done which opens up the possibility to plan that, as opposed to this is an emergency situation, we need to do some side dress, where do we find some equipment. Now we've got a fertilizer dealer actually promoting it with the equipment. And I'm not sure if they're responding to weather, or just it's a way to lengthen out their season as well (WI Advisor).*

Another NY farmer confirmed that salespeople and private consultants are imperative because, from his point of view, a farmer just cannot be an expert in the many technical aspects of farming. Here is what he had to say about industry specialists:

*... [information] always seems to come through the industry specialists ... I was petrified when I graduated ... I forgot what I knew, and I don't know enough, and this sucks, and I'm an idiot, and boy this is rough.*

*Then you just realize you don't really have to know anything, but you've got to know someone who does, your nutritionist is a way better nutritionist than you are (NY Farmer).*

Industry groups disseminate information to farmers through newsletters, factsheets, websites and journals. One NY advisor gets a lot of his information from Wisconsin through the Professional Dairy Producers of Wisconsin (PDPW):

*... I just looked at their [PDPW] website yesterday ... they have all their trainings categorized online in webinar form so you can click on them, and if you wanted, they have calves, and they have things about hooves ... and I look at Pennsylvania's ... but Wisconsin by far is providing that opportunity for ... a webinar ... you can watch at your leisure when you have time ... if you need information to know about heat stress ... it's all there ... (NY Advisor).*

Sources of weather and climate information included television, radio, websites and apps for mobile devices. Weather Underground, Weather Bug, Accuweather, the National Weather Service, and NOAA were mentioned as useful sources. For example, 'Weather Underground' was cited in three out of the six groups. A NY farmer reported that he likes Weather Underground better than other sources because it includes data from a station that is very near his fields, and it provides estimates for how much precipitation will fall along with the probability:

*Weather Underground is more precise, they're not always more accurate. They will tell you you're going to get 4.12 inches of rain you know between set hours ... (NY Farmer).*

Ideally, this farmer would like the weather forecasts provided to be more precise and more accurate, a desire expressed multiple times in these groups. None of the participants identified information from scientific research forums or climate panels as sources of information about weather and climate for their operations, nor did they cite any sources of seasonal or longer-term forecasts as significant to their decision making. This underscores a reality that farmers are not accessing the most recent climate change science to inform their decisions and rely on Extension, consultants, or companies as translators or a bridge to recent research.

Table 4 summarizes the emergent themes along with some emblematic quotes from this study.

**Table 4.** Emergent themes in dairy farmer and advisor focus groups in NY and WI.

Themes	Emblematic Quotes
Climate change impacts on the dairy farm	<i>"It seems like what's really affecting us is when we get excess rainfall in June ... "</i> WI Advisor
Management practices and decision making	<i>"... with the weather events, the heavy rainfall, ... with their no-till ground, you can get on the ground way quicker than if you have tilled ground ... "</i> WI Advisor <i>"We sold our equipment, and then hired in bigger equipment. ... more or less just for forage quality, but it all comes back to the window. The window's only so big (due to wet fields)"</i> WI Farmer
Climate change beliefs	<i>"I think that we are seeing changes; whether it's our fault, I'll leave that up to God ... "</i> NY Farmer
Climatic and non-climatic risk perceptions	<i>"... in dairy we export more and more of our product and ... if you ... lose the export markets, then it's all flooded back on the domestic; it becomes a profitability problem because milk prices tank."</i> NY Farmer
Sources and needs regarding weather and climate information	<i>"They're always interested in what their neighbor's doing."</i> WI Advisor

#### 4. Discussion

Farmers and their advisors in NY and WI are perceiving the impacts of climate change on their dairy farms. Dairy stakeholders were both exposed and sensitive to many climate-related impacts, as per a conceptual framework of vulnerability [17] which had implications for their adaptive capacity. However, the elements of vulnerability—exposure, sensitivity, and adaptive capacity—varied among individual farmers and advisors and across focus groups.

From the perspectives of exposure and sensitivity, participants indicated that the impacts most severely affecting operations were extreme precipitation events, drought and wet conditions, and to a lesser extent heat stress and other temperature-related effects. These climate variables align with those whose changes are projected to most seriously affect agricultural production in the Northeastern and Midwestern US [12,31,51,52]. The various effects of extreme precipitation events, including erosion and the shortened windows, appear to elicit the most vulnerability, aligning with previous findings in the Northeastern and Midwestern regions [13,15,16].

Focus group participants indicated that they possessed the adaptive capacity to be able to address the risks posed by a changing climate. As indicated through these focus groups in NY and WI, farmers have begun to implement many adaptive practices that are relevant to the region, including shifting planting and harvesting dates, experimenting with new crops or varieties along with new crop rotations, improving drainage, utilizing cover crops, and switching to reduced tillage or no-till practices [13]. As noted in previous studies [13,15,53], these findings reinforce that personal experiences with extreme weather events are a prime motivator for adaptation. Importantly, in this study, the extreme weather events raised by participants served to amplify and multiply existing risks such as restrictions from manure regulations, risks to profitability, and access to high quality labor.

#### *4.1. Climate Change as a Risk Multiplier*

As established in this work, farmers do not view climate change as a clear and present risk to their operations in and of itself. Instead they are focused on ongoing risks of a type that have been familiar to farmers for decades or longer, such as soil loss, rainfall and drought, regulatory restrictions and uncertainty, market pressures, and other issues that impact the day-to-day and year-to-year management of their operations. This is supported by other work on climate risk perceptions [8,15,54]. However, many of these issues could well be exacerbated by a changing climate.

Consequently, it would be reasonable to frame climate risk not as a new independent risk factor considered separately from existing threats to the stability of farm systems, but rather as a risk multiplier that has the potential to increase the severity and/or frequency of some existing risk factors. Climate change can be expected to increase weather variability, leading to more frequent droughts and extreme rains. This in turn increases the risk of soil loss and the difficulties of nutrient management. These uncertainties then feed into the regulatory and market spaces.

The opportunity that this presents is to frame climate risk not as a new, separate, and distinct threat to producers, but rather as an amplification of pressures for which they already have adaptation strategies. One distinct message that was presented multiple times in our focus groups was the idea that dealing with risk is “just farming”; farmers have existing skillsets that allow them to address these issues, and they are confident in their ability to do so. Farmers repeatedly stated the need for improved weather forecasting and so demonstrated their openness to advanced meteorological products. This same openness could potentially be leveraged to link climate risk to their ongoing decision-making processes while reducing the risks of politicization and blaming that reinforce their sense that they are serving as scapegoats to the broader public.

An example of how climate change may be having a multiplier effect on other risks is highlighted in the shortened windows during which fields are sufficiently dry to be worked without causing damage. These shortened windows can create competition among farmers for the same labor and equipment, such as manure haulers and spreaders, planters, and harvesters at the same time, and thus the dairy farmers’ adaptive capacity can be diminished when multiple risks are simultaneously compounded.

Conversely, during drought conditions, feed prices rise, threatening farm profitability. Thus, narrow profit margins affect adaptive capacity, assuming that milk prices do not compensate for increased prices of inputs. Therefore, according to these farmers and advisors, adaptive capacity is dependent on profitability because it costs extra money to adapt and to prepare for future extreme events. The more profitable businesses can afford to adapt and take a risk on implementing new,

experimental resilience practices, while farmers whose profit margins are relatively tight have less adaptive capacity.

Adaptation to the shortened windows was occurring in both states, but in different ways. In WI, the response to these events seemed to be with bigger, heavier equipment, which often led to soil compaction that had to be repaired. In contrast, the NY farmers and advisors in this study implied that the relatively small, sloping fields of NY were not as conducive to large equipment, but four-wheel drive tractors were necessary, and sometimes smaller equipment was required to get on the fields as soon as possible without causing as much compaction. This finding may have been a result of our sampling. However, as many of the Wisconsin farmers were from areas with larger, flatter landscapes. Adaptations in Wisconsin would be expected to differ in the hills that are more similar to the farms studied in NY.

#### 4.2. Manure Handling

Reported methods of manure handling differed between the two states. Draglining and injectors were very common among WI farmers and advisors, while NY groups emphasized manure haulers and spreaders. As with the equipment differences described above, geography, especially topography, is likely a factor in the adoption of draglining in particular. Draglining is more difficult on hilly terrain where the fields often have trees between them as buffer zones, riparian zones, and shelterbelts. In order to add draglines, some operations are removing trees and field barriers to expand the fields to allow them to drag the lines. This could influence soil erosion, runoff, and water quality. Perhaps as importantly, the shortened windows issue compounds challenges for applying manure to fields by any method.

#### 4.3. Climate Change Beliefs

The expressed beliefs on climate change were varied. Most farmers expressed that the recent climate differed significantly from earlier years. However, there was not broad agreement on whether this was due to variability within a stable climate, a changing climate due to natural processes, or a changing climate caused by human activities. Ultimately, farmers seemed not to feel that this was a relevant question to them in their decision making; reacting to the weather, whatever it might be, is something they feel is just a normal aspect of farming.

Many farmers expressed skepticism of anthropogenic climate change, and they were generally not adopting mitigation practices. Although some of the selected adaptation strategies such as rotational grazing and no-till may also contribute to mitigation, the mitigative benefits were generally coincidental rather than a purposeful, primary goal. The advisors did mention the role of cover crops and other practices that can have both mitigative and adaptive value as being especially useful. However, the lack of mitigation mentioned has implications for agricultural resiliency, both now and in the future. As others have noted [15], 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 could influence the ability of farming operations to remain resilient to climate change in the future.

Although personal climate change beliefs do appear to inform farmer actions, their influence on adaptation practices should not be overstated. Others [54] have 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 making farm management decisions. Although the dairy farmer participants could financially justify practices with immediate operational benefits (installing tile drainage), others with higher costs (investing in solar panels) or operational challenges (cover crops) were prohibitive. This supports findings from that a substantial barrier to on-farm adaptation is farmers believing that the costs of doing so are too high [12]. 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.

#### 4.4. Economic Risks

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, they perceived vulnerability in their long-term economic viability due to negative public perception of agriculture, burdensome regulation, and global trade politics which affect supply and demand. Although farmers in this study were implementing many practices that increase climate resiliency such as adopting no-till, planting cover crops, and increasing soil health, climate change was not the primary driver of these decisions. This too reinforced findings [12] that planners should pursue adaptation and mitigation strategies that simultaneously address multiple concerns. For example, adaptation to flooding and wet fields that can also increase 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 to ease the economic worries of farmers.

#### 4.5. Limitations of the Study

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 dairy farmer and advisor perspectives on climate change in the Northeast and the Midwest. As a qualitative study, the intent was not to generalize but to provide rich description, particulars and specifics from the participants [49]. 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 [50]. For future quantitative studies, random sampling that covers dairy 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.

### 5. Conclusions

This study contributes to our understanding of how dairy farmers in NY and WI are perceiving risk and making changes in response to the increase in extreme weather events and climate change. Framed in terms of presumed linkages among vulnerability, risk, adaptation, and mitigation, the findings in this study indicate that dairy farmers are indeed perceiving vulnerability to, and risks from, climate change. However, financial and economic pressures, perceptions of risk from non-climate-related sources such as the effects of consolidation in the dairy industry and global trade politics, as well as a skepticism towards anthropogenic climate change, appear to be limiting the extent to which farmers are willing to consider adaptation practices and the adoption of mitigative actions. Importantly, this study underscores that climate change is a risk multiplier for dairy operations and suggests that dairy farmers are at risk of increased vulnerability as climate change and its multiplier effects intensify in the future.

Given that the local impacts of climate change seem to motivate farmers' adaptation behavior instead of mitigative action [55], researchers and extension professionals may have the greatest impact through specific strategies that can help realize the co-benefits of 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) [12]. 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 regardless of how farmers view the idea of climate change [45].

Research and Extension outreach must identify strategies that not only address the co-benefits of adaptation and mitigation, but also address 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 encourage adaptation and mitigation practices. Likewise, policies that strategically promote the link between farming practices

and climate change adaptation and mitigation to the general public may help generate demand for agricultural goods produced according to climate-smart techniques and thereby help ease farmers' concerns that negative public perception is a threat to their livelihoods. Adaptive and/or mitigative action will most likely occur if farmers perceive that their economic needs and other concerns are being addressed and regulations allow them to adapt without going out of business entirely. Working with farmers and advisors to develop and communicate strategies that convey multiple benefits from a particular practice change is essential for any future research and educational endeavor.

The findings from this study identify important common themes among dairy farmers. Because risk and vulnerability are structured not only due to biophysical processes, but also socio-political ones, deeper analysis of demographic characteristics (gender, socioeconomic status, ethnicity, race, etc.) would provide better insight into how experiences, barriers, and opportunities vary among different farming operational types and sizes. The findings from this study provide important groundwork for future studies to build upon so that dairy farmer and advisor perspectives are both better understood and taken into consideration as the agricultural sector in the Northeast and the Midwest US continue to adapt to climate change.

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## Appendix A

### *Semi-Structured Focus Groups with New York Dairy Consultants and Advisors*

#### Focus Group Interview Guide

**Moderator Introduction:** (0:00) Hello, my name is (introduce self and present team members). Thank you for attending the Focus Group meeting today. Introduce team.

We are research and extension specialists from Cornell University, and we're interested in learning more about how dairy farmers in New York make decisions on their farm related to extreme weather and climate variability. With this in mind, we'd like to talk to you tonight about climate impacts in this region in this region. Thinking about the farms you work with, what impacts have you seen from those events and how has that impacted people's production? How are farming practices changing in response. Some examples of these changes we are observing in New York include: an increase in extreme heat or cold temperatures; increases in extreme precipitation (flooding), or lack of precipitation (short term drought); changes in seasons; and changes in diseases or pests.

Please feel free to speak openly and freely about your experiences, but we would also ask you to be respectful of everyone in the group. Our goal is also not to debate the science of climate change tonight, but to hear about risks farming operations, and what management decisions are being considered. Since we have limited time, I will try to keep the conversation on track as much as possible and make sure that we have a chance to hear from everyone. Before we proceed, I'd like to take a minute to go over the consent form and demographic form that are front of you that we would like to ask you to review and sign—there are two copies of the consent form, and you can feel free to sign both and keep one for yourself.

*(Review consent form: reiterate that participation is voluntary and that participants may leave at any time).*

<p><b>Participant Introduction:</b> Let's start by going around and having everyone quickly share 3 things about yourself: Your name, what type of farming you advise, and where your clients' farms are located.</p>
<p>(1) (0:15, 10 minutes) New York has experienced a number of unusual weather events or changes over the past ten years, such as extreme rainfall or short-term drought, heat waves, changes in the growing season, and increases in pest and disease pressure. As a consultant or advisor, have you or your clients experienced any impacts or events similar to these? If so, what were they?</p> <p>a. Briefly tell us about a memorable event or impact you recall. How did this affect the farm(s)?</p> <p><i>GOAL: Identify farmer concerns around extreme weather and increased climate variability, and how it relates to farm decision making. Should lead to discussion of potential adaptation measures.</i></p>
<p>(2) (0:25, 10 minutes) Have the farmers you work with made any changes to their farm operations (such as changes to farming practice or infrastructure as a result of the events or impacts we just talked about?)</p> <p>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 are the main motivations for making those changes?</p> <p>b. Do you feel that your clients are well prepared for similar events in the future? Why or why not?</p> <p><i>GOAL: Identify farmer values and changes in practices already made to adapt to climate change, and how this relates to farm decision making.</i></p>
<p>(3) (0:35, 10 minutes) What do you feel are the most significant risks to dairy operations that you work with now, and over the next five years? How do extreme weather and climate concerns compare or fit in with these risks?</p> <p>a. What do you feel are the most significant risks to dairy farm operations related to extreme weather and climate variability?</p> <p>b. We talked about steps some of you may have already taken to reduce risk in a previous question. What are your suggestions for how farmers can reduce these risks in the future? What are the main challenges or obstacles to you making these changes?</p> <p><i>GOAL: Understand farmer perceptions of risk and risk prioritization, and willingness to adapt around increased climate variability in the future.</i></p>
<p>(4) (0:45, 10 minutes) How well prepared are dairy farmers to handle any future climate risks?</p> <p>a. Which farms are more prepared and why?</p> <p>b. How do farmers learn about new research and practices that will help them become more prepared and resilient to extreme weather and climate change?</p> <p><i>GOAL: Learn how farmers view their decisions as reflected through the decisions of their peers. Learn about the role of peer networks in disseminating information.</i></p>
<p>(5) (0:55, 5 minutes) Where do the dairy farmers you work with currently get the information that helps inform their decisions about extreme weather and climate change?</p> <p>a. Family or Peers?</p> <p>b. University researchers, Cooperative Extension, federal agencies, state agencies, farm advocates (i.e. Farm Bureau, others)?</p> <p>c. Websites? Apps? Newspaper, Radio? For example:</p> <ul style="list-style-type: none"> <li>• The Weather Channel</li> <li>• iPhone or android default weather app</li> <li>• National weather service</li> <li>• Weather Underground</li> <li>• Accuweather</li> <li>• Local TV weather news</li> <li>• Radio</li> <li>• Newspaper</li> <li>• None</li> <li>• Other _____</li> </ul> <p><i>GOAL: Understand farmer information sources related to climate change.</i></p>

(6) (1:00, 5 minutes) Do you or the farmers use any of the following seasonal forecasting sources of information?

- National Climatic Data Center
- Northeast Regional Climate Center
- NOAA Seasonal Outlook
- The Weather Channel
- The Farmer's Almanac
- None
- Other \_\_\_\_\_

*GOAL: Understand farmer information sources related to climate change.*

(7) (1:05, 5 minutes) Do you or the farmers use any online tools for weather/climate-related decision making?

- Network for Environment and Weather Applications (NEWA)
- Northeast Regional Climate Center
- Cornell Climate Smart Farming (climatesmartfarming.org)
- Growing Degree Day Calculators
- The U.S. Drought Monitor
- Climate Hubs Toolshed
- U.S. Climate Resilience Toolkit
- None
- Other \_\_\_\_\_

*GOAL: Understand farmer information sources related to climate change.*

(8) (1:10, 10 minutes) When looking at the next five to ten years, what type of information or online decision tools do you or dairy farmers need to help respond to increasing extreme weather and climate risks on the farm?

*GOAL: Understand farmer information and training needs.*

(9) (1:20, 10 minutes) Most scientists believe that human activities are causing the rapid changes to the Earth's climate we are seeing observing. What role, if any, do you believe agriculture has in reducing the impact on the climate?

- Have any of the farmers you work with made any changes to increase the energy efficiency of the farm or use renewable energy (solar, wind or biogas)?
- Have any of the farmers you work with conducted an energy audit on the farm, or do they plan to conduct one?
- Have any of the farmers you work with put in place conservation practices or manure management practices that also help reduce the farm's carbon footprint?

*GOAL: Open a discussion of climate change and its relationship to agriculture. See how farmers react both to the question, and to each other's responses, and by extension how open they are to discussions and questions around climate science.*

#### **Closure**

(10) (1:30, 10 minutes) As we prepare to conclude this session, is there anything that else that you feel is important related to climate impacts and responses?

(1:40) Thank you very much for coming this evening. Your time is very much appreciated, and your comments have been very helpful.

## Appendix B

### *Coding Framework*

#### A Priori Codes and Sub-Codes

##### **Climate Impact**

- Higher temp/heat stress
- Extreme low temp/freeze risk
- Increased precip
- Flooding/wet fields
- Erosion/runoff/deposition
- Decreased Precip/drought
- Intensified biological stressors
- Wind/tornadoes
- Hail

##### **Change in seasons**

- longer/shorter
- Personal experience with extreme weather event
- Opportunities

##### **Adaptation**

- Changed practice
- Willing
- Challenges/barriers
- Reason for change:
- Values and priorities
- Reduce risk
- Economics
- Environmental stewardship

##### **Mitigation**

- Installed solar
- Installed wind
- Energy/GHG audit
- Installed biogas/digester
- Installed geothermal
- Willing
- Challenges/barriers

##### **Risk**

- General risk
- Regulation
- Labor
- Profitability
- Land tenure
- Climate risk

**Vulnerability/Preparedness/Resiliency**

- Farm
- Neighbors
- Peers
- Social network
- Family

**Needs**

- Information
- Tools
- Education/training
- Weather forecasts
- Decision tools

**Current Sources of Information**

- Family/peers
- University researchers
- Extension
- Federal agencies
- State agencies
- Consultants

**Climate Change Beliefs**

- Believe
- Uncertain about science/not solely human caused
- Do not believe

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