Is the Pasture Really Greener on the Other Side? Investigating the Vulnerabilities of Pasture-Fed Dairy Farms in Madison County, New York

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Colgate University, ENST 390
Fall 2014
# Table of Contents

I. Executive Summary ................................................. 3  
II. Introduction .......................................................... 4  
III. Methods ............................................................... 6  
IV. Results ................................................................. 6  
V. Discussion ............................................................. 9  
   1. Mitigation .......................................................... 9  
   2. Adaptation ....................................................... 12  
VI. Recommendations .................................................. 14  
VII. Conclusion .......................................................... 14  
VIII. Acknowledgements ............................................... 15  
IX. References .......................................................... 16  
X. Appendices .......................................................... 17
Executive Summary

This report examines the specific vulnerabilities and potential adaptations to climate change in the grass-fed dairy industry of Madison County, New York. This research was conducted for Colgate University, as part of the course Environmental Studies 390: Community-Based Study of Environmental Issues, taught by Professor Wyatt Galusky during the Fall 2014 semester.

In order to address the economic, environmental, and social components of sustainability, our group employed a multi-faceted research method involving three principal components. Our group conducted on-site interviews with local dairy farm owners, allowing us to get a more in-depth look at the various elements of grass-fed dairy farms as well as to establish a more natural dialogue with some of the local stakeholders. We also sent out an electronic survey to dairy farms in the county, which provided us with both qualitative and quantitative data concerning climate change and the dairy industry. Lastly, our group researched primary and secondary literature regarding the climate change, dairy, and sustainability to further expand our knowledge about the potential impacts of changing weather patterns as well as to look into possible adaptation strategies.

In analyzing our results, we found mixed attitudes towards climate change and the effects it will have on the grass-fed dairy industry: some felt that the weather effects of climate change will improve the grass-fed dairy industry for the northeast, others said the dairy farms will suffer from the weather extremes, and some were undecided. We researched the vulnerabilities the grass-fed dairy industry faced, specifically in the context of climate change. We looked into potential mitigation and adaptation strategies for consumers, dairy farmer, and local governance. For consumers, more awareness concerning what grass-fed products are and how they are made will help drive sales, increasing the market demand for grass-fed dairy, which falls under the economic pillar. In the environmental context, producers have a range of climate change strategies such as increasing the soil health and fertility, rotational grazing, increasing water storage facilities, and harvesting or utilizing different feeds for poor harvest seasons. In terms of the social pillar, many local dairy farms are family owned and operated so potential mitigation strategies for the local governance involve financial assistance such as subsidies and grant money that can be used to help these small-scale farms implement sustainable methods, though another possible approach might include creating policies aimed at maintaining healthy soil practices.

We recommend that the local dairy farms prepare for changing weather trends predicted by academic literature and begin to implement practices that will help them adapt over longer periods of time rather than adapting on a year-to-year basis. This involves ensuring that farmers will have appropriate supplies they will need, when they need them, in case of severe climate change effects leave them unable to acquire enough to maintain the farms. We also recommend that the local governments look into adopting policies supporting grass-fed dairy, such as incentives and subsidies, to help minimize the financial burdens of these farms to adapt to climate change.
Introduction

The dairy industry is a large and important industry in the United States because dairy is one of the staples of the American diet. The practices within the dairy industry of the United States have changed quite a bit over the past century. In the early 20th century the majority of dairy farms were pasture-based, required low input to maintain and had relatively low milk production (Capper, Cady, & Bauman, 2009). As demand for dairy products grew, conventional dairy practices began to become more popular because the high input, high production style was better suited to meet the demands of the market (Capper et al., 2009). In the 1990’s there was a change in consumer preferences created by social movements that opposed industrial agriculture and advocated for the health and environmental benefits of grass-fed products (Weber, Heinze, & DeSoucey, 2008). The push for grass-fed dairy created a more substantial market than had ever existed before and led to a resurgence of grass-fed dairy style farms (Weber et al., 2008). Although modern day grass-fed dairy farming may look similar to dairy farming of the past, increased knowledge about the industry through scientific discovery makes grass-fed dairy farming of today far more efficient with a better end product.

There are numerous advantages to human health, the animals and the environment with a grass-fed dairy farm rather than a conventional grain-fed dairy farm. Grass-fed dairy products have several benefits to human health including a higher omega 3 to omega 6 fatty-acid ratio and higher levels of conjugated linoleic acid (Clancy, 2006). In addition to improving human health, grass-fed dairy cows tend to be healthier because they are less prone to disease when not confined to a small space, have less acid build up, and receive more nutrients (Clancy, 2006). A pasture fed dairy farm is also less harmful to the environment than conventional dairy farming. Pasture fed dairy farms, when well managed, generally have decreased soil erosion, increased soil fertility, and improved water quality due to decreased pollution (Clancy, 2006). Furthermore, pasture-based dairy farms generally have a lower energy usage from not having to transport feed (Clancy, 2006). Grass also demands less fertilizer compared to the food sources of conventional dairy farming and the fields have less nutrient loss because manure goes back directly to the field where the grass is grown (Clancy, 2006).

Although grass-fed dairy is generally more environmentally friendly than grain-fed dairy than grain-fed dairy, there has been a trend in the industry as a whole has been steadily become increasingly more sustainable over the years. Cows have become much more efficient in milk production due to better genetics, more nutritional diets, more knowledge about disease prevention, improved cow health and better overall management practices (Capper et al., 2009). In 1944, cows averaged 2074 kg of milk per year compared to 2007 where they produced an average of 9193 kg of milk per year (Capper et al. 2009). This higher efficiency in milk production has decreased both the proportional energy and resources required to maintain the cows and the environmental impact in term of greenhouse gasses (Capper et al. 2009). Although the carbon footprint per kilogram of milk in 2007 was only 37% of what it was in 1944, methane production from dairy cows and the deforestation needed to provide a food source for them are still a major environmental concern (Capper et al. 2009). Possible strategies to mitigate the
concern of greenhouse gasses on a global scale are: engineering better diets for cows, reducing meat consumption in high-income countries, or a consumer shift to more environmentally friendly practices, such as pasture fed dairy (Koneswaran & Nierenberg, 2008). Even though both grass-fed and grain fed dairy have become more sustainable in many aspects, grass-fed dairy is the better environmental option of the two.

Sustainability and environmental adaptability are vital factors for farmers to consider in the face of climate change. As climate change becomes a growing concern around the globe, changing weather patterns will affect the dairy industry of different regions of the world in a variety of ways. On an individual farm level there are concerns with heat stress on cows, droughts or flooding and how it affects grass growth, soil condition and the nutrient content of food sources (Parsons et al. 2001). Dairy cows are particularly sensitive to heat and see a decrease in milk production when temperatures rise above 77°F (Lal, Alavalpati, & Mercer, 2011). Because of this, northeastern dairy farms are expected to see a decrease in their July milk production (Lal et al., 2011). In the Northern parts of the United States it is predicted that the growing season for crops may actually increase with climate change, but higher crop production can result in increased risk of nutrient leaching and a more rapid breakdown of soil organic matter (Salinger, Sivakumar, & Motha, 2004).

Because of the potential negative effects of climate change to the dairy industry, there is a need to be able to adapt to the extreme varying weather conditions that are projected. It will be necessary for farms to adopt both environmentally and economically sustainable practices in the somewhat near future in order to maintain their farms and their war of life. The dairy industry has always required a high degree of adaptability to adjust to different weather year to year; however, the threat of more extreme weather due to climate change is likely to require more substantial preparation to mitigate negative effects. Despite substantial evidence for climate change only about many farmers do not expect to see any negative effects from it (Barnes & Toma, 2012). This stance may be problematic because due to the unpredictability of future weather patterns, farmers need to be prepared for the worst-case scenario to minimize any negative effects they face.

The dairy industry in Madison County, New York, is integral to the cultural identity of the area, and will likely face challenges from the unpredictability of weather due to climate change. The industry plays a dominant role in economy, culture, and environmental health of the local area, which makes the sustainability of the industry a concern for the future. This report will examine in what ways grass-fed dairy farms of Madison County are vulnerable to climate change, methods to adapt to the effects of climate change, sustainable measures available to the industry and how the industry will change in the near future. We will also offer recommendations to the local government, farmers and consumers of the community for strategies to improve sustainability of grass-fed dairy farming and modify current practices to adjust to climate change.
Methods

Our research method involved three main components. We conducted on-site interviews with local dairy farmers, sent out an electronic survey to dairy farms of all feeding methods in the surrounding area, and conducted literature research. We designed our methods so that all three pillars of sustainability as described by Boström (2012), were covered at some point. We defined the environmental pillar as anything involving the financial capital and commerce of the grass-fed dairy industry. The environmental pillar included everything pertaining directly to the health and viability of the earth and organisms involved with the industry, e.g. humans and cows. The social theme of sustainability covered the socio-political relationships and culture of the industry.

Our interview questions covered a variety of topics ranging from their personal and cultural connection to the dairy industry to what effects from climate change they have seen on their farms (Appendix 1). In order to clarify potentially ambiguous terms and statements, we asked participants to define sustainability in their own words as well. The electronic survey contained both qualitative and quantitative questions (Appendix II). For example, to gather quantitative data we included questions on how many cows does the farm have and how many acres are on the farm. For qualitative data, we asked questions about how climate change as impacted their dairy farms and what accommodations they have had to make because of those changes. According to Boström (2012), “The social pillar of sustainable development could thus be seen as including both procedural aspects, such as the role of democratic representation, participation, and deliberation and substantive aspects, that center on ‘what’ is to be done (i.e., the social goals of sustainable development)”. Thus, these interviews and survey were critical to the procedural aspects of sustainability in terms of the social pillar, as they provided an opportunity for the local dairy industry workers to participate in the research. By interviewing these farmers directly, we were given a more personal look at the very specific issues that these individuals have in the face of climate change and heard directly what they felt needed to be done. The other component of our method involves primary literature, which provided a more scholarly and quantitative data-driven aspect to our research, as well as background information on dairy industries and climate change at the national level that we could then apply to our particular context.

Results

Through utilization of our three research methods we were able to obtain data on the social, economic, and environmental components of the grass-fed dairy industry in Madison County and the nation. Through the interviews and literature review we were able to address key vulnerabilities of grass-fed dairy, as an industry in general as well as in the context of climate change.

We visited three farms in Madison County: Red Gate Farm, an Amish Organic Valley farm, and New Moon Farm. Red Gate farm is a pasture-fed farm of approximately 400 heads of milking cattle located within 10 minutes of Colgate run by Bruce Rivington, whom we interviewed on site. The Amish farm we visited, located in Canastota, is run by
Nathan Weaver and was part of the Organic Valley Co-op. The farm had about 43 milking cows and was a seasonal, grass-fed feeding style. New Moon Farm is owned and operated by Chris and Sarah Ficken in Munnsville and is mostly grass-fed, with some corn and grain supplemental feed with around 17 milking cows. Our interviews with the local dairy farmers proved to be the most valuable resource for determining vulnerabilities and potential adaptations associated with climate change. They also provided valuable insight into how deeply connected the grass-fed dairy industry was to the three pillars of sustainability.

In terms of the social pillar, we discovered the crucial role communities play in supporting the local dairy industry. Neighbors often help struggling or new farms by assisting in renovations, building projects, or offering advice. While most of the milk produced in these farms is trucked off to processing facilities by co-ops, many locals also choose to buy their dairy products from these farms in order to support the surrounding community. Sarah Ficken emphasized the importance of these connections: “We need to be socially responsible—be good neighbors, support the local community” (personal communication, November 6, 2014). We also found that unlike many industries, dairy farms most often are run as a family business; many are led by a father and son or husband and wife team and the family will work the farm as long as they are physically able. Because these farms are family owned and operated “many decisions are made around the dining room table,” indicating that these stakeholders have a much more intimate relationship with the way the farm is controlled (Sarah Ficken, personal communication, November 6, 2014). These dining room table decisions and community involvement underscore how critical the social pillar of grass-fed dairy is since this component of sustainability focuses on increased participation of local stakeholders in framing the issues, proactive stakeholder communication, sense of community attachment, and social recognition (Boström 2012).

We found that the economic aspect of the grass-fed dairy industry is multifaceted since many of the small-scale farms of Madison County sell their products in a variety of ways. A large number of the local farms sell their milk to co-ops, such as Agri-Mark and Organic Valley (Bravo-Ureta, Boris, & Lee, 1988) where it is combined and sent to manufacturing facilities to be processed and turned into products like cheese, raw milk, whey protein, and yogurt. Cooperatives such as this provide better financial returns and are generally well received by the farmers who see this as a more collaborative marketing and selling strategy (Nathan Weaver, personal communication, November 13, 2014). These non-milk dairy products like butter and yogurt capitalize on a niche market that is not subject to the constraints of standardized milk market prices and allow farmers to set prices that are more representative of the higher quality products (Bruce Rivington, personal communication, October 28, 2014). While not fail-proof, this option provides more economic stability and sustainability for grass-fed dairy since profit can be made even with less total production in times of severe weather. Though typically grass-fed dairy is perceived as being more expensive to maintain and produce, we discovered that the reality of the costs may be more similar to conventional dairy practices since often costs like gas used to truck in feed and manure are left out of the cost-benefit analyses of conventional dairy (Nathan Weaver, personal communication, November 13, 2014).
Since many of these grass-fed dairies sell their milk locally and often directly to friends and neighbors, negative economic and environmental impacts associated with transportation are lower than those of conventional dairies, increasing the sustainability of this industry. An important economic consideration of any dairy is the cost of starting up a farm, especially with the growing number of farms that are moving further north to take advantage of the cooler climate. Undoubtedly it takes a lot of capital to start up a farm, and many grass-fed dairies must also factor in the cost of buying grain and other feed substitutes in order to be able to fulfill the cows’ food requirements, depending on the condition of the land and how useable the pastures are (Nathan Weaver, personal communication, November 13, 2014). However, grass-fed dairy farms often require less equipment to maintain the health of the cows, especially with rising temperatures that are forcing conventional dairy farms to invest in expensive cooling and ventilation equipment (Salinger, Sivakumar, & Motha, 2005). Rising temperatures have been shown to decrease milk production in cows, so moving forward grass-fed dairy farms must keep this in mind when attempting to keep an appropriate level of sustainable production (Lee, Clark, & Roche, 2013).

Naturally, the environmental components of the grass-fed dairy industry are the primary focus when exploring sustainability and the effects of climate change. Grazing methods, such as management intensive rotational grazing, differ between farms and are largely determined by the farmer’s preference and amount of available land. Most often the farmers have to transform unusable field into usable pastures, requiring specific crops and overgrazing in order to rid the field of invasive plants and to put nutrients back into the soil (Nathan Weaver, personal communication, November 13, 2014). Sustainability of land use is viewed as needing “to be good to the land… if you rehabilitate the fields now, we’ll be reaping the benefits in the long term” (Sarah Ficken, personal communication, November 6, 2014). Lee et al. (2013) echo this sentiment and emphasize the importance of increasing the quality of the pastures in the first year: “the value of pasture renewal has been calculated to increase farm profitability through improved pasture production, nutritive value and persistence; however, for pasture renewal to be effective farmers must choose appropriate pasture species (and endophytes) and ensure careful management during the first year.” Farmers acknowledge that land use practices of the present could potentially ruin the viability of the farms in the future if not done with sustainability at the forefront. Surprisingly, we found in both the literature and personal interviews that the northeast is the most suitable environment for grass-fed dairy, as cows prefer the cooler temperatures and the lands are more hospitable to grazing (Salinger, Sivakumar, & Motha, 2005). This is very important to the sustainability of grass-fed dairy because milk production and the health of the cows are dependent on not only the weather, but the types of land on which they graze.

In our research, we identified several key vulnerabilities that grass-fed dairy farms have in the face of climate change. First and foremost, water is a serious concern for the future of this industry (Sarah Ficken, personal communication, November 6, 2013). Changing weather patterns are predicted to bring severe rains as well as severe droughts, both of which can be detrimental to the operations of grass-fed dairy. Torrential rain often causes flooding that makes the pastures unusable for cattle grazing; similarly,
excessive mud caused by large rainfalls can have negative impacts of the health of the cows. According to Lee, Clark, and Roche (2013) “farmers with waterlogged pastures also have the added difficulty of grazing waterlogged pastures without losing large amounts of pasture through treading and burial, and their subsequent impact on pasture regrowth.” In drought seasons, farms do not have enough water to feed their cows or grow the hay needed to supplement their diets (Barnes & Toma, 2011). Another related vulnerability is soil quality, which can have a far-reaching effect on the viability of grass-fed dairy farms. Soil erosion caused by severe rains or winds prevents farmers from being able to plant crops needed for winter silage, making farmers turn to outside sources for feed that is often much more expensive (Nathan Weaver, personal communication, November 13, 2014). Previous unsustainable farming practices are also a major contributor to soil vulnerabilities because farmers must put in a lot of work and money into making the land suitable for both grazing and crop planting (Sarah Ficken, personal communication, November 6, 2014). As climate change exacerbates the environmental damage nutrient-poor soils, it will become increasingly difficult for farmers to afford the costs and time associated with bringing the soil quality back to a level at which production will high. Extreme temperatures are a significant vulnerability for grass-fed dairy farms. While colder temperatures are generally favorable to cows, heat waves and overall temperature increases impact the milk productivity and health of cows, contributing to significant income losses for the farms (Barnes & Toma, 2011). Finally, the changing growing seasons make grass-fed dairy more vulnerable to climate change since many farmers rely on crops for winter feed sources (Lee, Clark, & Roche, 2013); consequently, any drastic change would affect their ability to maintain sustainable operation of their farm as the land’s ability to produce enough crops declines and the market price of essential crops increases.

**Discussion**

**Mitigation**

The market for grass-fed products has firmly established itself in recent years and continues to grow at a substantial rate. Dairy and meat products that were sold at a discount for being grass-fed ten years ago are now being sold at premium prices. Even though “Grass-fed meat and dairy producers still only make up about 0.2 percent of the U.S. meat and dairy sector” the last ten years have seen “the emergence of a new market niche [of grass-fed dairy products], a recognized and distinctive arena of production, exchange, and consumption” (Weber, Heinze, & DeSoucey, 2008). Due to this emergence into a larger market, the number of grass-fed dairy farms has increased as well. Since “by 2050, global farm animal production is expected to double from present levels,” it is not unreasonable to believe that the grass-fed dairy industry will continue to experience large amounts of growth in the future (Koneswaran & Nierenberg, 2008). With the future promising a significant increase in the number of grass-fed dairy farms, it seems obvious that the impacts from climate change that these farms will suffer will become much more apparent. Due to the stakeholder value that consumers of dairy have, they must also be responsible for the effects that dairy farms have on climate change. To this end, a key driver in mitigation efforts is consumer and buyer awareness.
Labeling and enabling consumer education on the differences that the farms have is also important to this mitigation process. Scherr and Sthapit (2010) highlight the impact the dairy industry has on greenhouse gas production very well when they state that a single cow/calf pair on a dairy farm in the eastern United States is “responsible for more greenhouse gas emissions in a year than a person driving nearly 13,000 kilometers in a mid-sized car.” It seems that currently, consumers are not aware of the large impacts that dairy production has on climate change and greenhouse gas production. In addition to this, “cattle raised on pasture, eating a more natural, low-energy diet composed of grasses and other forages, produce manure with about half of the potential to generate methane” (Koneswaran & Nierenberg, 2008). Since consumers are failing to recognize the impacts that traditional dairy farming has on the environment, it is fair to say that the general public also fails to recognize that grass-fed dairy farming has less of a negative impact on climate change when compared to conventional dairy. Increasing customer consumption of grass-fed dairy products would act as a mitigation strategy and would decrease the amount of greenhouse gasses emitted by the dairy industry as a whole due to a shift to where demand is. Consumers will take the needed steps once they realize that their choice of dairy products can have a greater impact on the climate than how far they drive their cars. While it is easy to say that reducing the consumer demand of dairy products in general could act as a significant mitigation technique, this would devastate the economic sustainability of the grass-fed dairy industry and expose it to even greater economic and environmental stresses. Therefore, while we cannot recommend that consumer demand for dairy be reduced, we do recommend that consumer demand for dairy be encouraged to switch from conventional to grass-fed.

While consumers can do some things to help mitigate the effects of the negative impacts of climate change on the agricultural sector, the producers may have the most power in reducing greenhouse gas emissions. While much of the current research focuses on CO2 as the cause of climate change, methane (CH4) has a higher global warming potential and is just as important to regulate its emissions. Koneswaran and Nierenberg (2008) highlight the impact that dairy can have on methane emissions when they state that “The animal agriculture sector is also responsible for 35–40% of annual anthropogenic methane emissions” and that “the emissions from the animal agricultural sector surpass those of the transportation sector.” Therefore, it is incredibly important that producers do everything they can to limit the amount of methane that their farms are producing. To this end, grass-fed dairy may be an answer. In fact, “cattle raised on pasture, eating a more natural, low-energy diet composed of grasses and other forages, produce manure with about half of the potential to generate methane” (ibid, 2008). If producers would make the switch from industrial dairy, where feedlot confinement and high protein feed is standard, to grass-fed dairy, it is possible to significantly reduce methane emissions. In this way, grass-fed dairy is already a kind of mitigation technique that can be aided and enhanced both by producers and consumers.

Supplements and additives could also reduce methane outputs by changing the microbiology of the cows’ rumen. This would be ideal for systems like the highly modernized and productive local Hamilton grass-fed farms because it is “appropriate for highly efficient systems, in which animals are in confinement for at least part of their
lives” (Dickie, Streck, Roe, Zurek, Haupt, Dolginow, 2014). Although economically difficult to balance, an extremely easy way to reduce greenhouse gas emissions on a dairy farm would be to reduce the number of cows.

Through herd management and breeding it is possible to reduce a farm's number of animals while still maintaining a set level of production. Simple actions such as “basic disease prevention and providing shelter for the animals” would give increased productivity and would lower the number of cows needed while things such as “high-end genetics” would lead to more productive livestock and the elimination of needing to keep breeding steers on the farm (ibid, 2014). In a more technological way, methane emission can be countered most effectively through the use of a methane digester.

Methane digesters are modern machines that make use of microorganisms to break down biodegradable material, in this case manure, in the absence of oxygen in order to produce gas to be used as a fuel. Gerber et. al (2013) highlight the importance of the future use of this technology when they state, “in North America, the wider use of anaerobic digesters — the option with the highest mitigation potential — could lead to a 12.7 percent reduction in emissions.” This may not be entirely practical for grass-fed dairy in Madison County due to how most grass-fed operations in Madison used their manure to fertilize their fields, and a methane digester cannot work on a field, only on the flat hard surface of a parlor. This would extremely limit the effectiveness of the technology. Also, the amount of money needed to have a digester is not something that the majority of small grass-fed dairy farms in Madison County have. So the local government must step up in order to help.

The local government role’s in mitigation is crucial to reducing greenhouse gas emissions of dairy farms. While the U.S. Supreme Court declared in April 2007 that the EPA has the authority to regulate carbon dioxide and other heat-trapping emissions from vehicles, it has not done so in other sectors. The same regulations should be put into place by local governments under advisement of the EPA on the dairy industry. Scherr and Sthapit (2010) bring up a good point when they say that “No such major shift seems likely without putting a price on livestock-related greenhouse gasses, so that producers treat them as a business cost and thus have a direct incentive to reduce them.” By applying a local tax on livestock related gas emissions, dairy farms will be incentivized to burn off or collect and mitigate their emissions and they may even attempt to increase the amount of carbon storage that their land is capable of. The true root of the problem of attempting mitigation is related to the large costs that follow mitigation techniques.

The government could also be instrumental in aiding dairy farmers who wish to implement mitigation techniques but lack the economic resources to do so. As discussed earlier, the most effective way to reduce methane emissions is through the extremely expensive methane digester. Government subsidies and loans could lessen the cost of effective, yet expensive, mitigation techniques. Even having subsidies for farmers undertaking the simple mitigation strategies such as rotational grazing, feed choice and manure burnoff could incentivize farmers to reduce their greenhouse gas emissions. Furthermore, offering subsidies for choosing to change to grass-fed or pasture dairy
farming could also have a positive mitigation effect. The local government can also have a large role in the education of the public and thus the mitigation effect that the consumer has. By effectively educating local populations on global climate change and the differences that the public can make through their consumer choices, the local government can be an effective tool to aid consumer and therefore producer mitigations.

Producer Adaptations

Soil and Grass Quality

One important strategy grass-fed dairy farmers should consider is to improve the soil fertility of their pastures because of the variety of environmental benefits it provides. Increasing the soil fertility of pastures will not only optimize grass production, but also provide more nutrients to the grass, which in turn means the cows are receiving a more nutritious diet (Watson, Atkinson, Gosling, Jackson, & Rayns, 2002). In order to increase soil fertility and organic matter in the soil farmers would need to ensure dairy cows have a nutritious diet, so those nutrients can return to the soil in the form of manure and also never stir the field with a plow (N. Weaver, personal communication, November 13th, 2014). In addition, changing crop varieties can improve the organic matter levels in the soil (Salinger et al. 2004). Having high levels of organic matter is also vital to the health of the soil. A high level of organic matter can improve the resiliency of soils because it allows the soil to absorb a high quantity of water (N. Weaver, personal communication, November 13th, 2014). This has several implications in the context of climate change. If a farm is facing high temperatures and drought conditions, the organic matter will retain more water and prevent the grass from dying as easily (N. Weaver, personal communication, November 13th, 2014). Conversely, if a farm is facing heavy rains and flooding conditions, the organic matter will help absorb excessive water and prevent soil erosion (N. Weaver, personal communication, November 13th, 2014). An increase in organic matter in the soil also has the potential to decrease carbon dioxide levels (N. Weaver, personal communication, November 13th, 2014). Improving the quality of the soil that cows graze on is a long-term solution that will keep both the fields in good condition and the cows healthy.

Another possible adaptation strategy for dairy farmers is rotational grazing. Rotational grazing allows for the fields to revive after they are grazed on so the roots of the plants recover and resources to renew so the grasses will not suffer excessive grazing and die (Beetz & Rinehart, 2004). Transitioning from a continuous grazing style to a rotational grazing system creates a more efficient farm that could potentially double the forage and increase pounds of animal production per acre (Beetz & Rinehart, 2004). Although rotational grazing requires more land and capital investment, the increased efficiency of the farm and healthier fields will contribute to the sustainability of the farm in the face of climate change. Many farms already practice rotational grazing due to the many benefits it provides. Those who practice continuous grazing and have the land to switch to rotational grazing so should consider switching grazing styles.
Drought and Flood Condition Flexibility

With the likelihood of variable levels of precipitation in the future due to climate change, it is important to prepare for a variety of conditions. Implementing wells, ponds, and other water holding facilities are important tools to catch water and make it last longer in order to adapt to periods of drought like conditions. Ponds and wells are particularly valuable in conditions with intermittent periods of heavy rain and dry periods (S. Ficken, personal communication). Being able to save excess water in periods of high rain and use it during dry periods is vital keeping the grass in pastures alive and for keeping cows hydrated. Ponds are useful tools to catch water because they can help prevent any unnecessary soil erosion (C. Ficken, personal communication, November, 6, 2014). Periods of heavy rain may also require that pastures have better drainage to minimize flooding. Better drainage will help keep the grass healthier, create less mud (making it easier for cows to navigate pastures) and limit soil erosion. Because varying amounts of precipitation is a particular concern in the Northeast of the United States, strategies to better manage water in both flooding conditions and drought conditions is going to be vital for the future of dairy farming in Madison County.

Dairy farms producing their own hay silage is another strategy to adapt to conditions that do not permit the growth of grass. Currently, grass-fed dairy farms in Madison County rely on hay silage during the winter when the pastures are no longer suitable for grazing. Producing extra hay silage for periods of droughts and flooding is another options farmers have to keep their cows fed throughout all conditions, which improves the resiliency of the farms. If farmers grow their own hay, they will not be dependent on favorable weather conditions for grazing or be forced to import food during periods of poor conditions. The more food sources farmers have available to feed their cows, the more flexible they can be in the face of varying weather. Many farmers will produce their own hay silage provided they have the land for it. Farmers that currently purchase their own hay silage should consider devoting the land and other resources required to produce it to improve their flexibility.

Weather Predictability

One interesting technology that can aid dairy farmers in their adaptation to the variable weather patterns is seasonal and inter-annual climate prediction (Salinger et al., 2004). The development of this technology will allow farmers to be able to receive a more accurate estimate of what the weather for each year so they can implement any adaptations necessary to minimize problems due to weather. Increased preparedness will lead to better environmental, economic, and social outcomes in the grass-fed dairy industry (Salinger et al., 2004). This technology would allow farmers to be proactive with the adaptive measures they make, rather than reactive. A better prediction of seasonal weather will also allow dairy farmers know when the growing season will start and how long it will be.
Local Government Adaptations

There are also several measures that local governance can take to aid in the adaptability of dairy farms. Scientists and farmers need to work with policy makers to foster an environment where the adaptation strategies of farmers can be effective (Salinger et al., 2004). Policies need to be created that support grass-fed dairy farmers and encourage farmers to increase their sustainability. One possibility would be a policy that incentivizes farms to maintain a certain level of organic matter in their soil. This would benefit the farmers from both an environmental and economic standpoint by making their grass more resilient to weather and more nutrient-rich. The local government should make policies that encourage farmers to adapt to climate change and provide guidance on how to do so.

Local government can also help farmers adapt to climate change by providing economic support. The local government can give grants to grass-fed dairy farms in order for them to increase their sustainability and adaptability to climate change. This grant money can be used for things such as improving the quality of soil, building water holding facilities, creating better drainage of pastures and implementing more efficient practices. The government can also subsidize grass-fed dairy during difficult stretches of bad conditions to help keep farms economically viable. Another possibility is having the local government subsidize dairy products that are sold locally, which will help promote the local economy and minimize environmental impact. Buying local products will support rural areas and allow consumers to directly support the farmers in their community. Consumers are likely to want to buy local products (assuming they are affordable because of the subsidies), and this will help strengthen the bond between the local producers and consumers.

Consumer Adaptations

Consumers can also play a role in promoting adaptability for grass-fed dairy farms. Consumers should consider purchasing grass-fed dairy products because of the health and environmental benefits of the products. Consumers should not increase their dairy consumption overall, but rather transition to buying grass-fed dairy products instead of grain-fed products. By choosing to support the grass-fed dairy industry, they will expand the market for these types of products and therefore encourage this style of farming. If grass-fed dairy products become popular in the market, they can use the profits to implement adaptive strategies on their farms and become more sustainable. Consumer support is essential to the sustainability of the grass-fed dairy industry.

Recommendations and Conclusion

Climate change will prove to be an increasingly persistent problem for agricultural industries in the immediate future. Local farmers and communities are going to have to actively make changes to become more sustainable and live in a world with a high variability of weather conditions. We have several recommendations to be best prepared for the future.
Farmers currently adapt to changing weather patterns on a yearly basis. Despite the constant variability in weather patterns, dairy farmers have been able to adjust and to maintain healthy production levels. However, because weather patterns are likely to become more extreme than in the past, it would be advantageous for farmers to prepare for climate trends based on academic data and adapt over an extended period of time. Many farmers are still uncertain about the effects of climate change, but in order to maximize preparedness for the future, they should expect the worst (Barnes & Toma, 2012). In order to improve sustainability, efficiency, and adaptability to weather, farmers should implement as many adaptation and mitigation strategies as possible. Since factors such as financial means and access to available technologies affect the feasibility of implementing these sustainable methods, careful consideration must be used in determining what is appropriate for each part of the grass-fed industry.

The local government should create policies that support the grass-fed dairy industry and encourage the farmers to adopt adaptation and mitigation strategies. The government should create incentives for farms to become more sustainable and be better prepared for the future, in order to ensure the survival of the industry in the face of climate change. Furthermore, the government should encourage farmers to sell locally for both economic and environmental benefits.

Despite the fact that Madison County is well suited for dairy farming and climate change will potentially have a less significant impact on Northeast compared to other regions of the United States, we recommend that farmers, local governments and the community take a proactive approach to improving sustainability. It is important to maximize preparedness for climate change so that productivity of the farms remains constant. By adopting a reactionary stance to climate change, it is more difficult to adjust to problems that occur and the efficiency and productivity of the farm may suffer. Being prepared for climate change is vital to keeping the grass-fed dairy industry of Madison County intact and profitable and therefore essential for maintaining the cultural identity of the area.

Acknowledgments

We would like to thank Professor Wyatt Galusky, Bruce Rivington, Sarah and Chris Ficken, Nathan Weaver, Steve Bossard, Marie Anselm, the Case-Geyer and DLMC library staff, and the rest of the ENST390 class for providing us with data and helping us throughout this project.
References


**Appendices**

Appendix I. Questions used for on-site personal interviews with local dairy farmers.

**Interview Questions**

1. Talk about the history of your farm.
   a. Has your farm always been grass-fed?
2. What are the benefits of having a grass-fed farm?
   a. Are there any drawbacks from having a grass-fed farm?
   b. Why did you decide to have a grass-fed farm?
3. Can you tell us about the process making your product?
   a. How do you sell your product?
4. Describe your cultural connection to the dairy industry.
5. How would you define sustainability?
   a. Do you feel that the concept of sustainability applies to your industry?
   b. Have you actively made changes to your farming practices to become more sustainable?
6. In what ways has climate change impacted your farm?
   a. In what ways did you have to alter your practices to overcome the stress of climate change?
7. Has the competition for land had any impact on your farming practices?
8. How do you expect the dairy industry to change with the stresses of climate change?
9. In what ways do you anticipate your farm changing in the future due to climate change?

Appendix II. Questions used in the electronic survey sent out to local dairy farms.

Electronic Survey Questions

1. What is the name of your farm/business?
2. What is your name?
3. What is the feeding style of your farm?
   a. Pasture-fed
   b. Grain-fed
   c. Other (please specify)
4. How many cows do you have on your farm?
5. How much land do you have on your farm? How much of that land is used for grazing? (If applicable)
6. What is the average lifespan of the cows on your farm?
7. What is the average weight (pounds) of milking cows on your farm?
8. How much milk do you cows produce per day? How many days per year do you milk the cows?
9. What products do you produce?
10. Where are your products sold?
11. How long has your farm used grass-fed methods? (If applicable)
12. Do you rotate the grazing on the pasture? If so, how long is each rotation?
13. About how much manure do your cows produce in a year? (If applicable)
14. What do you do with the manure? (If applicable)
15. How many people work on your farm?
16. Have you seen any effects from climate change on your farm? If yes, what kinds of effects?
17. What type of changes have you had to make to accommodate for climate change?