Animal Agriculture in a Changing Climate

Adapting to a Changing Climate

A Planning Guide

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Agriculture is changing rapidly. Industry consolidation, vertical integration, globalization, integration of technology, food security, genetic modifications, rapidly expanding world population, and a variety of other changes have offered a variety of opportunities as well as challenges for farmers. A changing climate is yet another challenge that farmers and the agricultural industry need to address through both long and short term planning.

About this planning guide

This planning guide leads livestock farmers or advisors through four steps to strategically plan and prepare for a changing climate. The document includes an explanation of each step along with guidance on planning for a specific farm. These four steps require:

- Assessing current climate trends
- Evaluating farm vulnerabilities and opportunities based on these climate trends
- Selecting appropriate options to prepare and adapt to these climate trends
- Compiling all of the information in a farm-specific climate adaptation plan

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Introduction

Today, U.S. farmers produce 256% more food with 2% less inputs than in 1950 (American Farm Bureau). However, agricultural production remains an economically risky business. More than any other business, the risks in agriculture come from the uncertainty and variability in weather. Fortunately, current farming systems are typically robust enough to accommodate nearly all but the most extreme weather conditions. Over time, farming practices have developed to buffer environmental impacts. Northern regions use shelters to protect animals from cold and snow. Roofed and shade structures are used in Southern regions to protect animals from direct sunlight. Irrigation systems are used in drier regions to produce high corn yields on a consistent basis. When environmental conditions (typically temperature and precipitation) fall within the normal bounds of variability our production systems are generally profitable.

The challenge comes when weather conditions become more variable or more frequently fall outside the normal bounds for which our farming systems are designed.

The systematic approach outlined in this guide can be used by livestock and poultry producers who are interested in developing a plan to deal with a changing climate. The approach uses four steps: assessing local climate trends, evaluating the impacts from or the vulnerability of the farm to these climate trends, evaluating options to cost effectively reduce these impacts, and finally combining this information into a simple plan that can be followed and updated as needed.

This guide provides both background information on these critical elements of planning along with a worksheet to help organize a planning document.

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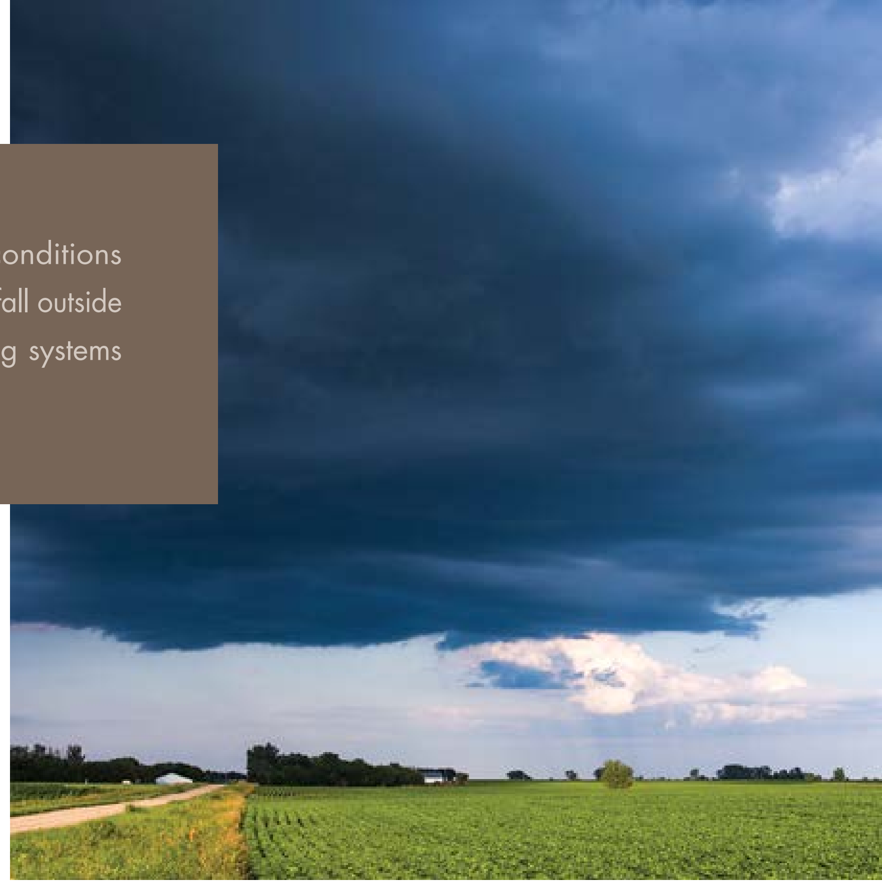

Step 1
Identify Critical Climate Trends

The climate is always changing: ice ages, extreme periods of drought (Figure 1), long warming trends, long cooling trends, etc. Everyone agrees that today's climate is different from past climates just as the future climates will be different than what we have today. The problem is that society's infrastructure (e.g. transportation system, population centers, buildings, agricultural systems) are based on the climate of the last 100 years or so. As climate changes, our current infrastructure systems may not be adequate, especially those systems that are most vulnerable to changes in weather such as agriculture.

Climate refers to average weather conditions over a long period of time, whereas weather is what is happening when we look out the window. Unfortunately, our expe-

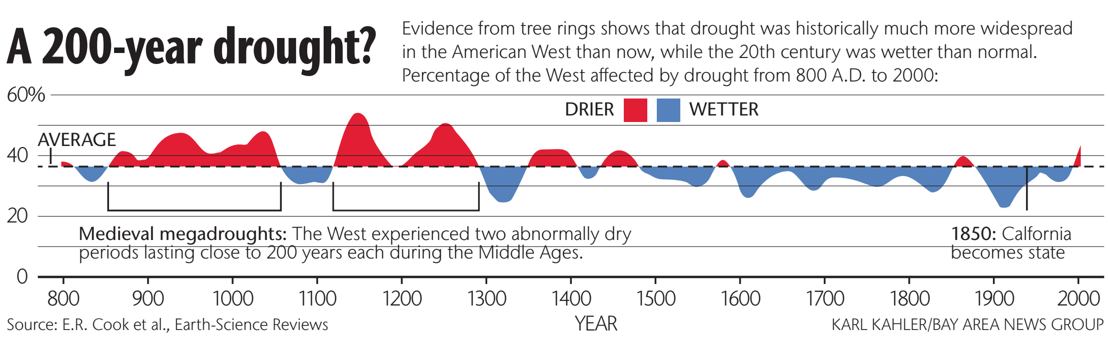

Figure 1. Historic drought in Western U.S.

rience of recent and local weather often overshadows the reality of how the climate is really changing. For instance, unseasonably cool weather in Nebraska "this past month", does not suggest the planet is cooling any more than the drought in Texas "last year" suggested the planet is getting dryer.

Climatologists find meaningful trends in climate ONLY as they observe weather data over long periods of time and over large geographic areas. Climate trends can be evaluated over periods of ten or twenty years, but are typically evaluated over several decades or hundreds of years. While climate variability may be observed in as short as a few years, climate change is typically evaluated over several decades to hundreds of years.

The analysis of climate over various time periods is important as it provides different information. For example, Figure 2 shows the annual Palmer Hydrologic Drought Index (PHDI) for California. The left graph shows the 15-year period between 1998 and 2013 and right graph is a 128-year period, from 1885 to 2013. Both graphs show an increase in drought conditions. However, the trend is more dramatic in the shorter time period. Which referenced time period is more realistic or useful when planning for the future? "Both" as each trend tells something a little different. The long-term trend gives some confidence that the last few years are not a random occurrence and the short term suggests an even greater potential for dry conditions in the near future.

Figure 2 also shows the common cyclical patterns of wet and dry periods. Several years of above normal precipitation followed several years of below normal. These multi-year trends are also important to note—especially in short term planning.

Another observation with these graphs is that there is rarely a "normal year" as the "normal" is made up of averages of wetter and drier years.

Mixed in with these normal variations in climate conditions are extremes. There are years where the PDHI is far away from

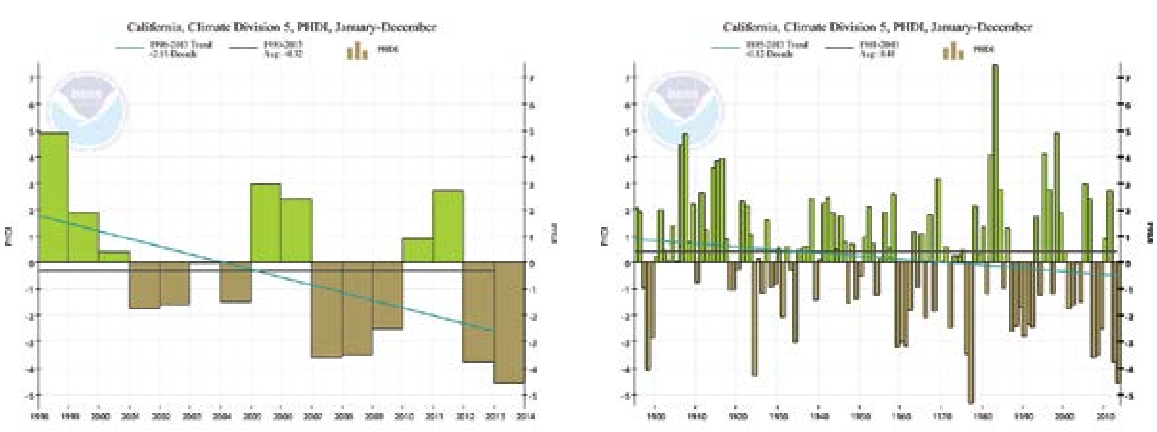

Figure 2. Palmer Hydrologic Drought graphs (NOAA NCDC, Climate at a Glance)

Photo credit: www.agweb.com

the average and outside of the normal variation (e.g. Figure 2, year 1986). Extremes in temperature or precipitation are the most challenging as they lie outside of the normal bounds of the design parameters for our current farming systems. For example, manure storage and runoff control systems are typically designed for 25-year, 24-hour events. Large 50- or 100-year events overwhelm these systems causing significant or catastrophic failures.

Climate models can provide additional information about future climate conditions. Climate models are based on fundamental scientific principles and include all known drivers and variables of climate change—both natural and man-made. However, there is uncertainty in climate model predictions, just as there is uncertainty in predicting stock market performance despite all the data analysis. Yet, this information helps inform investment decisions.

While historical climate data and climate models cannot precisely predict future climate conditions, the information from both sets of data can provide clues to the future climate that should be used in farm planning.

Key Climate Change Data Considerations

The following is a list of important considerations when evaluating climate changes.

- Climate trends vary over time. Long- and short-term historic data must be evaluated simultaneously along with future climate predictions. Short-term assessments help in planning for next year or the following

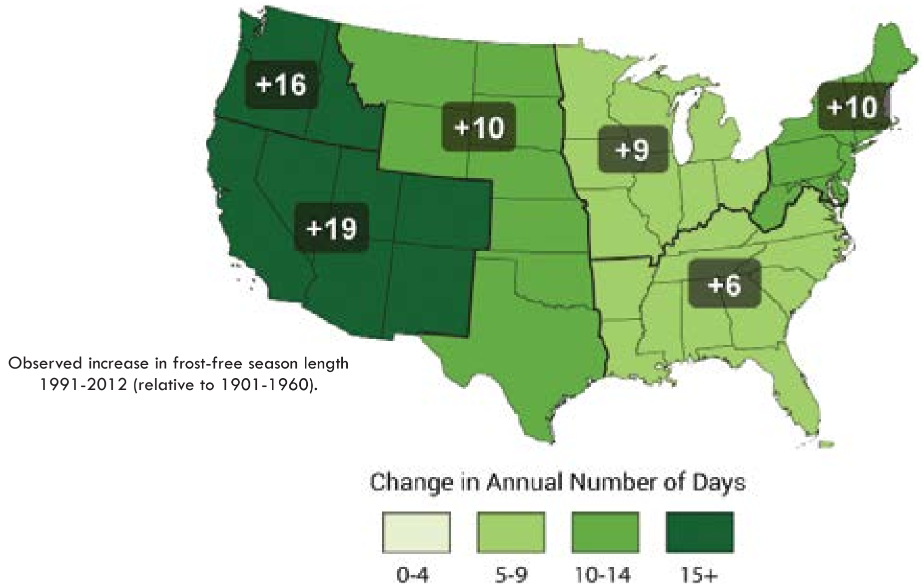

Figure 3. Change in frost free season (days) from the 2014 National Climate Assessment.

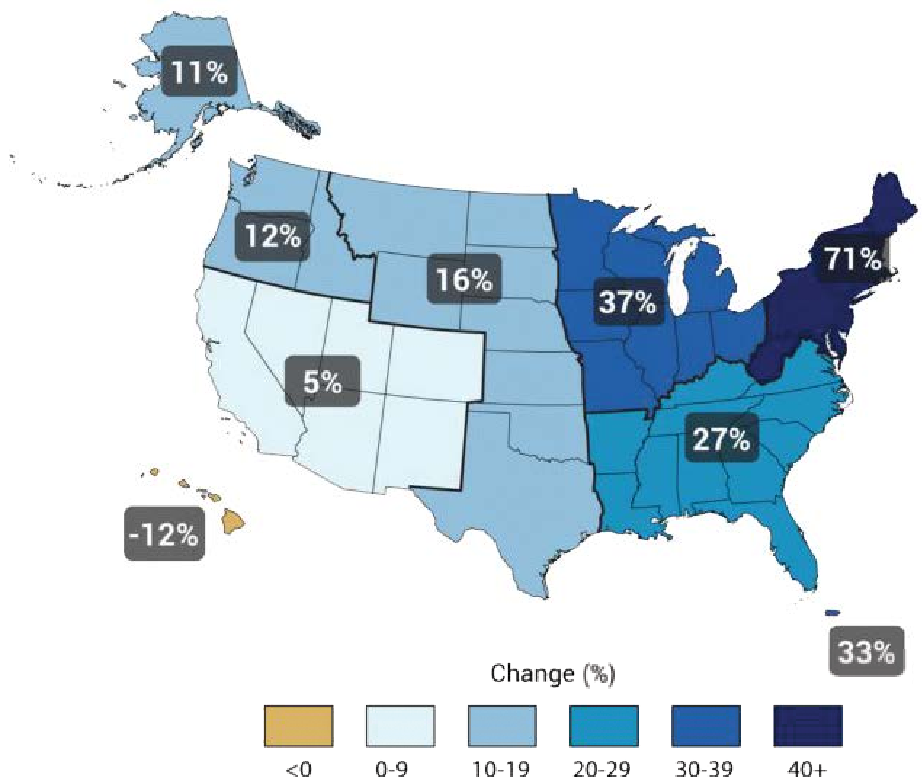

Figure 4. Changes in extreme precipitation events (events over 1 inch per 24 hours). Source: National Climate Assessment, 2014.

year. Long-term trends and future predictions help guide farm business planning over the next 15-25 years.

- Climate trends vary geographically. Local climate trends provide guidance for farm specific planning. Trends over larger geographic regions (national and global) help shape decisions on future markets for farm imports or exports. For instance, heat and drought conditions in New Zealand in 2013, a globally important dairy region, had a significant impact on global milk prices (Hannam, 2013).
- Climate trends are both annual and seasonal. In some regions, annual average precipitation or temperature is not changing. Other regions are seeing significant shifts in seasonal temperature and precipitation.
- Climate trends have both indirect and direct impacts on animals. Increased nighttime low temperatures can have a direct impact on animal performance. Average temperature and precipitation changes can also have an indirect influence on animal production because of the impact these changes have on crops andforage productions.
- Climate trends include the frequency and intensity of extreme weather events. Knowing average annual or seasonal precipitation and temperature trends is important, but possibly more important are changes in the rainfall intensity (the amount of rainfall per event) or the frequency of these intense rainfall events. The same is true for the frequency of extreme heat events.

Finding Climate Trend Data

A climate assessment should be as complete and detailed as possible—considering the most important climate conditions that directly or indirectly impact animal production. General climate trends can be found in the National Climate Assessment (*http://nca2014.globalchange.gov/*) with graphs similar to those in Figures 3 and 4.

There are also online tools that can provide climate trend details. *NOAA's "Climate at a Glance" tool* is a quick way of evaluating historic trends over the last 100 years and allows for finding temperature or precipitation trends on a monthly or seasonal basis. Figure 5 shows a graph of summer temperatures in the Midwest produced using the "Climate at a Glance" tool. The graph includes the 100-year trend line, but the tool can also show trends over other time periods.

Another useful tool that can provide a variety of weather data at a local, regional or state level is the *cli-MATE tool from the Midwest Regional Climate Center* (*http://*

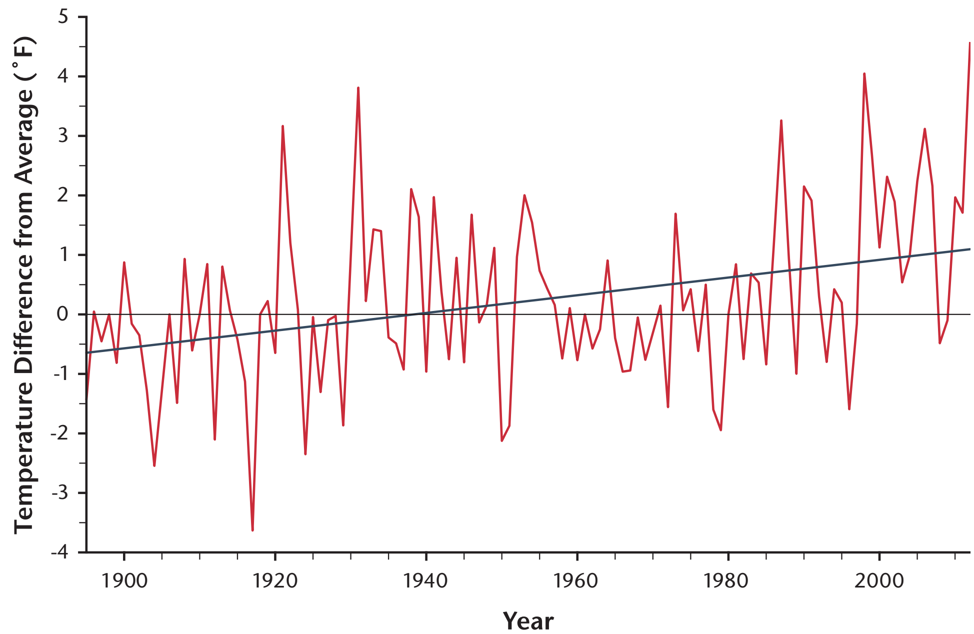

Figure 5. Midwest average annual temperature trend from the 2015 National Climate Assessment.

mrcc.isws.illinois.edu/). This tool has the ability to generate daily threshold data and min-max data which is useful when evaluating trends in heat stress potential. Another option for collecting this data is to ask your state climate office. There are also six Regional Climate Centers that may be able to provide useful trend information (NOAA, *https://www.ncdc.noaa.gov/customer-support/partnerships/regional-climate-centers*).

Worksheet 1 in Appendix 1 offers a way to summarize the critical climate trends for animal agriculture on both a seasonal and annual basis. Use the sources above to determine any trends in your region. Include any additional notes that might be helpful.

"Risk is a measure of the probability and consequence of uncertain future events." Yoe (2012)

Step 2
Evaluate Farm Vulnerabilities

The next question to answer is "Which changes in climate represent the biggest risks or levels of concern?" Risk is a measure of the probability and consequence of uncertain future events (Yoe, 2012). This involves estimating both the probability of some event occurring (e.g. heat wave) and the consequences of a specific event (e.g. death loss, reduction in productivity, damages). This is no easy task.

Overview of Impacts or Consequences

General consequences of heat and humidity on animal agriculture are fairly clear. A study in 2003 (St. Pierre et al) estimated losses to the animal industry to be $2.4 billion per year due to decreased performance, increased mortality, and decreased reproduction associated with heat and humidity. There are likely more indirect losses not accounted for.

More recently, the 2014 drought in California resulted in a 3% loss in beef production and a 1.5% loss in milk production with estimated total direct losses to the agricultural industry of $1.5 billion (Howitt et al., 2014).

There are also impacts (consequences) resulting from changes in climate variability. South Dakota ranchers are familiar with blizzards in December, but not in early October as was experienced in 2012. Animals were not yet acclimated to the cold. Also, the rain started before the snow causing the ground to become wet and muddy, adding to the animal stress. Over 7,500 cattle deaths were reported from this unexpected weather event (Zhorov, 2013).

Summaries of these national, regional, or industry-wide impacts are useful, but assessments are also needed at the individual farm scale. On an individual farm, consequences of weather events vary by species, geographic location, existing management and infrastructure. Any assessment of weather impacts must be seasonally specific and consider individual phases or segments of their operation or business (cow calf vs feeder operation) and geographic conditions within a farm (e.g. pasture, cropland or specific buildings prone to flooding).

Attaching some economic value to these impacts is important yet challenging. Historic on-farm records are the easiest and most common source of information. Farms with good records can make some economic impact assessment based on animal productivity during warm periods, wet periods, or extreme weather events and can then use this information to assess impacts for future climate events.

If there is no farm-specific data, historic data from other farms or regions could be used. For instance, to quantify impacts of heat stress on beef feedlots, it may be helpful to look at the report by Busby and Loy (1995) that documented cattle death loss of 4.8% in a 13-county area in Iowa for a 2-day heat event on July 11 and 12, 1995. This 4.8% death loss could be an estimate used for an early season heat wave in some other region of the U.S.

Critical Weather Impacts

The following is a review of how some very familiar weather events can directly or indirectly impact a farm.

- **Heat and Humidity:** Depending on the timing and duration, heat and humidity impacts animal production in a variety of ways including reproduction, feed efficiency, milk production, animal illness, grain and forage production, increase in pests or timing of pest impacts, animal death, changes in nutrient value of crops, worker health, etc. *Temperature Humidity Indexes (THI)* are used to help assess animal stress for the different combinations of temperature and humidity as each animal species and stage of production are impacted differently. Even small changes, such as warmer nighttime temperatures, can have a significant impact in animal production. High heat and humidity on a larger scale, national or global, can impact the price of feed supplies or price of farm products.
- **Precipitation:** Wetter conditions, dryer conditions, intensity of rainfall or timing of rainfall all impact animal production. Obviously, drought can lead to crop and forage losses, but also results in soil loss through wind erosion. Soil loss also occurs with large or intense rainfall events. This soil loss has a long-term impact on farm-

land productivity. Manure storage and manure application can be challenging with large precipitation events. Muddy pastures, feedlots, and roads also create production and health challenges.

- **Extreme Events:** Extreme weather such as widespread flooding, drought, blizzards or tornados all can lead to catastrophic losses on the farm. Flooding can impact local bridges or roads causing logistic challenges for transporting feed and supplies to the farm or for exporting farm products. In addition, flooding may impact employees' ability to get to work. Power outages, wind damage, snow loads, etc. create additional challenges to farm operations.
- **Climate Variability:** It is often not the event itself that causes the problem but the timing or circumstances that cannot always be quantified by climate data. Early season high temperatures or cold temperatures may not be outside the normal ranges of temperatures but can be devastating to animals.

The process of developing a climate change adaptation plan requires a systematic approach to assessing the risk. One systematic approach follows the flow of the farm: Farm Inputs, Production, Logistics, and Farm Exports.

- **Farm Inputs:** Farm inputs include items such as feed, water, young stock, veterinary supplies, fuel, and electricity. Animal feed is one of the most critical farm inputs. Local grain, forage or pasture production can be devastated by heat, flooding or drought. Regional or national climate changes (hot, dry, wet, cool) can result in increased or decreased cost of feed. Higher temperatures increase animal water consumption requirements. This increased need for water may occur concurrently with limited water availability in cases where there is both heat and drought. With high temperatures and drought conditions, farm ponds can also become toxic with algae or dry up completely. The timing of natural stream flows may change due to snow melt or changing rainfall patterns. Young stock coming on to the farm may have been raised in areas impacted by drought or heat, or may have been exposed to other

pathogens or pests. Their weight or health may be impacted. Delivery of young stock to farms can be delayed because of high temperatures or extreme storm events. Delivery of other supplies to the farm can be impacted by extreme weather as storms can impact roads and bridges inhibiting the movement of other supplies brought into the farm such as medicine.

- **Animal Production:** Animal production includes all aspects of maintaining good animal health and productivity. Impacts of heat and humidity on *animal physiology* are well documented and summarized by (Nardone et al, 2010). This includes reductions in feed intake, feed efficiency, reproduction changes and even death loss. In addition, heat stress can make animals more vulnerable to pathogens and various diseases.
- **Logistics:** Farm logistics include manure handling, ventilation systems, structures, employees, movement of feed to animals or of animals to feed, but also include other activities, equipment and processes to keep the farm operational. Many farm activities, such as moving feed to the farm, moving young stock to the farm, moving products from the farm, feeding and watering animals, keeping animals comfortable, moving manure to the fields, etc. depend upon weather conditions. Flooding creates problems for manure management due to concerns about overtopping of manure storages and creating soggy soils for land application. Flooding can also take out roads and bridges that may impact labor supply or moving feed or animals into or out of the farm. High temperatures may impact when animals can be fed or moved. Electric power outages often accompany these extreme events—adding additional management challenges.
- **Farm Exports:** The price for farm products is critical to farm profitability. Market price of these products (e.g. meat, milk, eggs) is often a function of climatic conditions across the globe. Local drought or flooding may cause a regional increase or decrease in commodity prices. Large-scale drought may increase feed prices which result in a sell off

of animals which decrease the price of the farm products. This might be followed by a reduced inventory and increasing prices.

Third party evaluators, such as Extension Agents (Educators) or farm consultants with knowledge of the farm operation as well as experience with the interactions of climate change and animal agriculture may be in the best position to objectively assess farm climate vulnerabilities.

Quantifying the Impacts of Climate Change

Understanding or quantifying the consequences of a weather event is difficult but not nearly as challenging as estimating the probability of their occurrence. Unlike insurance companies who calculate the probability of a person being in a car accident based on records of millions of drivers and

Table 1. Example of recording key vulnerabilities for specific weather events.

Impact Category	Projected Weather	Impact Summary/Consequences (Specific to season and phase of production)
Farm Inputs	Decreased summer precipitation	Currently all cropland is sensitive to limited rainfall. Pasture areas use farm ponds for drinking water. Pasture areas do not have adequate moisture in the fall.
	Higher heat/ humidity	Early spring warming changes pasture grass mix.
	More frequent flooding	Heifer pasture #17B is prone to flooding.
Animal Production	Heavier spring rains	Muddy pastures reduce weight gain.
	Higher heat/ humidity	High humidity at night limits cooling of animals. Dairy heat stress is already an issue in August. Nighttime cooling is critical. We are already seeing problems with heat stress impacting production.
Logistics	Heavier spring rains	Manure storage is limited. Heavy rainfall will likely result in overtopping of manure storage.
	Higher heat/ humidity	Ventilation system can't keep up during hot weather. Animal transportation is already a problem due to hot weather.
	Extremes	No back-up generator. Some pastures are very remote and difficult to access if there is flooding.
Exports	All weather	I market only one commodity to one buyer. This makes me vulnerable to local weather events and global weather extremes.

miles traveled, extreme climate events are rare. Although there is some data available for things like 25-year or 100-year rainfall events this does not really represent the probability of site-specific flooding. There is no good data on return frequencies of other events such as extreme heat or humidity. We can only look at recent weather trends and make reasonable estimates of probabilities.

For example, if it is clear that flooded pastures are a current issue on your farm and weather projections indicate a trend toward more intense precipitation events, then this should be a priority for adaptation.

Worksheet 2 in Appendix 1 provides an example of how to combine impacts with anticipated trends in weather events. The first column is the list of the impact categories. The second column lists the projected trends in weather events for your local area as noted in *Step 1: Identify Critical Climate Trends*. The third column would provide information on *Step 2: Evaluate Farm Vulnerabilities*. Try to provide as much detail to these impacts as possible including economics. For instance, will this type of event result a 1% death loss or a 10% reduction in productivity over a 6-month period? Often there is not good data on these losses but only educated guesses.

When filling out Worksheet 2, think about weather impacts on the farm that are currently causing a loss in productivity or economic losses. For instance, there may already be problems with high temperatures impacting productivity. It is OK to list these current issues.

> "The goal of risk management is often said to include scientifically sound, cost-effective, integrated actions that reduce risks while taking into account economic, environmental, social, cultural, ethical, political, and legal conditions." Yoe (2012)

Step 3
Identify Adaptation Strategies

Reactive or Proactive Risk Management

"The goal of risk management is often said to include scientifically sound, cost-effective, integrated actions that reduce risks while taking into account economic, environmental, social, cultural, ethical, political, and legal conditions." (Yoe, 2012). Modern farming has reduced risk over time by developing sophisticated ventilation systems to deal with heat, irrigation systems to aid in times of limited rainfall, and modifications to crop genetics to protect against weeds, diseases, drought or temperature extremes. Other tools such as flood insurance or forward contracting of commodities help reduce agricultural business risks. This type of adaptation to manage risk is driven by a response to historic climate trends or recent weather events and is referred to as *reactive adaptation.*

Many fear that responsive adaptation may not keep pace with the current pace of climate change (Walthall, 2012). This is especially true with longer term investments such as buildings, herd genetics, or management of pastures and grasslands. These longer term investments must anticipate environmental conditions for the next five, ten, twenty or thirty years. For example, given the current and projected drought conditions in California, would this be a good location for a new dairy facility? Adaptation based on projected climate conditions is called *proactive adaptation.*

Evaluate Adaptation Strategies.

Producers are familiar with the many technologies and management practices that can reduce the impacts of a variety of rainfall and temperature conditions. Diet, ventilation and cooling, feed procurement, feed management, crop or animal genetics, etc. all qualify. These risk management strategies must be evaluated on the basis of costs and benefits or *return on investment (ROI).* ROI is calculated as the financial gain from the investment minus the cost of the investment divided by the cost of the investment. For example, if $10 is invested and results in a gain of $20, the ROI is:

$$\frac{(\$20 - \$10)}{\$10} = 1$$

An ROI above zero indicates a positive return on the investment.

The problem is projecting this ROI with all the uncertainties both in the future climate and in the other multiple factors in business operation. Also, in the case of climate and weather, the investment decision may not be based on an ROI above 0, but rather a way to minimize the consequences. For example, purchasing flood insurance does not yield a positive ROI, but is a viable risk management strategy That minimizes economic losses in case of a flood.

Making decisions based on an uncertain climate future is challenging. A quote from the Iowa Beef Center Producer Survey by Busby and Loy (1995) raises the challenge: “How much can a feedlot operator spend to protect against a weather event that has occurred only six times in the last 101 years?” This is a critical question that must be asked. However, another equally critical question is, what if this heat wave occurred on average every 10 years? 5 years?

or 2 years? The more frequent the impact, the wiser or more necessary the investment in some type of adaptation strategy.

However, the adaptation decision is typically even more complex as there is never just one adaptation option. For instance, a shade structure is only one option for keeping cattle cool. There are also sprinkler systems, fans, and misting systems along with changing herd genetics for greater heat tolerance.

These climate adaptation decisions are also not made without considering the many other future uncertainties such as variability in market prices, product demand, feed supply, water availability, regulations, and other parameters influencing farm profitability. Risk management requires a reasonable and measured approach to this uncertainty and careful evaluation of most likely scenarios.

Risk management or adaptation is not a 'one size fits all' or a menu of options. Rather, risk management is a continuum of options that are farm specific. Some risk management strategies offer significant risk

Table 2. Examples of impacts and risk management options.

Impact Example	Adaptation Options: Low Cost	Adaptation Options: Long Term + More Expensive
Increase in higher intensity rainfall events damages cropland and pasture due to additional soil erosion	• Alternative pastures in rotation • Alternative crops or plants	• Install terraces
Extended or extreme dry weather reducing forage in pastures	• Reduce animal density • Secure additional feed • Cover crops, drought tolerant forages with longer roots for grazing purposes	• Add more pasture land • Application of organic material (i.e., compost) to increase soil water holding capacity
Increased frequency of pest and weed pressure in field	• More intensive scouting	• Change crop rotation • Crop/forage diversification
Increased potential of manure storage overtopping with variable timing and intensity of rainfall	• Maintain higher freeboard by pumping more frequently • Find emergency option for pumping manure	• Add more manure storage
Unseasonable / frequent hot weather impacting animals	• Feed for hot weather • Install more fan capacity • Install sprinkling system • Reduce time in holding pen (dairy)	• Add evaporative cooling system • Invest in new cooling technologies
Farm is more frequently landlocked due to excessive or increased flood events	• Increase feed supply on hand	• Add storage capacity for product (milk / eggs) • Repair / upgrade farm access

reduction for very little cost while other strategies are long term and require a large investment. Strategies or options are a function of 'most likely climate changes' along with site geography, current management, current finances, long term and short-term farm goals, personal preferences, cultural beliefs, and other factors.

Worksheet 3 in Appendix 1 provides examples of farm impacts along with adaptation or risk management options. Note that the probability of these climate events, the degree of impact of these events, and the costs of the adaptation strategies are not provided.

Some of these strategies may be economically profitable with or without any change in climate. For instance, good forage or pasture management may be cost effective with or without future changes in precipitation. Pest management or scouting (Integrated Pest Management) is also cost effective in any climate situation. Maybe it is just more emphasis or focus on this area of business. Sometimes just the threat of climate change may be a driver to make changes that are reasonable under existing climatic conditions.

In addition, there are many low-cost strategies that offer significant protection from negative impacts of climate change. An adaptation strategy for early season heat stress might be as simple as making sure misting systems are operational in April rather than waiting for July to do this annual maintenance. This is a no-cost risk management strategy requiring only good planning and organization.

Step 4
Implement the Plan

This planning guide is intended to stimulate ideas that are site specific and will help in both short and long-term planning to reduce the risk of climate impacts. Although the steps are sequential, it is important to know that this type of planning is never static. It is a constant cycle of identifying climate trends, assessing potential impacts or farm vulnerabilities, making and updating plans, and then implementing adaptation strategies.

Here is a brief summary of the steps used to develop an adaptation plan. These steps are part of the process to develop a plan. Implementing the plan is Step 4.

Step 1: Identify Critical Climate Trends

- Using the local or global climate resources, identify the short- and long-term climate trends.
- Determine the most likely climate scenarios for one-, five-, and ten-year periods. Include seasonal trends in precipitation and temperatures, length of growing season, nighttime low temperatures, drought frequency and any other weather events deemed important.
- Document your source of information.

Step 2: Evaluate Farm Vulnerabilities

- Consider potential impacts to: farm inputs, animal production, logistics, and farm exports.
- Try to estimate the damage cost for each of the impacts on an annual basis.
- Identify the most likely and most critical impacts.

Step 3: Identify Adaptation Strategies

- Conduct a detailed evaluation of one or two options to reduce the risk of each of the critical impacts.
- Estimate the cost of a technology or practice on an annual basis. Include additional benefits from the implementation of a technology that should also be included. For instance, adding pasture area may have a positive impact throughout the year on the herd not just during a specific flood event. These additional benefits should be noted.

Step 4: Implement the Plan

The objective of this final step (Step 4) is to create a concise plan that can be put into action and updated annually. Here are some key pieces to keep in mind with this plan. A template of the final plan is in Appendix 1.

- The plan must be simple, only one or two pages. It must address the most critical farm impacts and proposed adaptation strategy.
- The plan should summarize key information in Steps 1-3 in the planning followed by a short list of action items.
  - Are there some more pieces of information that need to be researched?

- Are there bids needed on equipment costs for specific equipment?
- Are there some farm management procedures that need to be written or training that needs to be done?
- Add a timeline, if appropriate, to complete the action items in the plan.
- Add some guidance for returning to the plan and reevaluating the climate impacts, effectiveness of the adaptation strategies, and any changes that are needed.

- Do not put this plan on the shelf. Put it on the refrigerator in the break room! The plan was developed with input from others and contains valuable information. Share the plan with the management team and discuss implementation. Get it done!
- Try to document the effectiveness of the changes made to address climate change.
- Summary: Although this process and guide was written as a stand-alone planning guide for adapting to climate changes, all of this planning and evaluation should be integrated into the overall business planning for the farm. Decisions for farm expansion, herd genetics, planting dates, crop genetics, employee training, etc. should always be made considering a changing climate.

Appendix A
Adaptation Plan Template

Complete the four steps in the following pages for your farm. This will help you to:

1. Assess current climate trends in your region;
2. Evaluate farm vulnerabilities and opportunities based on these climate trends;
3. Select appropriate options to prepare and adapt to these climate trends;
4. Compile all of the information in a farm-specific climate adaptation plan.

Identify Weather Trends

Determine the most likely climate and weather trends over the next one, five or ten years.

+ = INCREASE
– = DECREASE
⊘ = NO CHANGE

Climate	Spring	Summer	Fall	Winter	Annual
Average Temperature	+ – ⊘	+ – ⊘	+ – ⊘	+ – ⊘	+ – ⊘
Nighttime Low Temperature	+ – ⊘	+ – ⊘	+ – ⊘	+ – ⊘	+ – ⊘
Precipitation Amount	+ – ⊘	+ – ⊘	+ – ⊘	+ – ⊘	+ – ⊘
Precipitation Intensity	+ – ⊘	+ – ⊘	+ – ⊘	+ – ⊘	+ – ⊘
Growing Degree Days	Average:				+ – ⊘
Return Frequency Drought	Average Years Between Events:				+ – ⊘
Return Frequency Large Rainfall Events	Average Years Between Events:				+ – ⊘
Other Notes					
Source of Data					

***When looking at any of this information, please remember that winter is considered to be December through February, spring is March through May, summer is June through August, and fall is September through November.*

Identify Impacts and Vulnerabilities

List farm-specific impacts or vulnerabilities resulting from the anticipated climate changes on Worksheet 1. Include cost estimates of these impacts.

Impact Category	Projected Weather	Impact Summary/Consequences (Specific to season and phase of production)
Farm Inputs		
Animal Production		
Logistics		
Exports		

Identify Management Options

List some of the most significant and likely impacts from Worksheet 2 in the first column of this table. In the second column, list technologies or management practices that might reduce negative impacts. List the short term and "quick" fixes first and the longer range planning second.

Critical Impacts	Technology/Management to Reduce Impact (Quick Fix)	Technology/Management to Reduce Impact (Long Range)

Implementing My Adaptation Plan

Write your adaptation plan and steps for implementation. (Use one form for each Critical Climate Change)

Today's Date: ______/______/______

Summary of Critical Climate Change

Summary of Most Critical Farm Vulnerabilities

Summary of Most Likely Adaptation Strategies

List of Actions Steps

Appendix B
Example Adaptation Plan

Adaptation Planning Example: 5,000 Head Beef Feedlot in SW Iowa

Summary of Critical Climate Change

- Prediction based off of historic trends: Earlier spring warming period.
- Past trends: (for this county) indicate about 5 days per year where the low temperature is above 72° degrees (concern for heat stress).
- Current trend: Average annual temperatures are increasing. Recently there have been several years with more than 8 days with nighttime low temperatures above 72° F.
- Additional: Based on current trends in my region found on the climate addition, a heat wave is expected 1 in 4 years in this area.
- Source: Midwest Regional Climate Center (cli-MATE)

Summary of Most Critical Farm Vulnerabilities

After reviewing all of the potential impacts, we determined that our biggest concern is death loss from these infrequent but extreme events. (Busby and Loy, 1996 AS R1348 Iowa Extension fact sheet) show heat extremes of as few as 2 days can result in a 4.8% herd death loss in unprotected herds in addition to other performance losses because of these temperatures. For this 5,000 head feedlot, the loss would be approximately 240 head. Using a quick estimate of 1,000 lb. average weight on the lot and live-weight prices of $1.25 per pound, we can assume one event of this magnitude would be a loss of $300,000. With a return frequency of one in five years, this is about $60,000 per year in death loss alone. There may be other losses with less extreme heat events.

Summary of Most Likely Adaptation Strategies

The farm currently has limited shade structures to protect animals. At times, the farm uses a water truck to sprinkle the cattle during heat events. This works well but is costly. Recent data shows a sprinkler system costs about $25 per head (www.feedlotenvironmental.com), but costs can be quite variable depending on elevations and the potential need for a new well. Assuming $25 per head, the total cost would be $125,000. Given the current frequency of heat events, the system will pay for itself quickly on death loss alone. Should heat event frequencies increase, the system will have a higher positive return. Other things to consider are more shade structures, better access to water and management procedures to put in place during heat events.

List of Actions Steps

- Get better estimates on the exact cost of a sprinkler system in order to fine-tune the numbers for death loss and losses in efficiencies due to heat stress.
- Investigate options for more shade cloth (costs + benefits.)
- Make a decision within two months on practice to install.
- Evaluate in one year the effectiveness of the practices and revisit the climate impacts and trends.

Appendix C

References

Climate Trend Data Sources Recent Trends

- NOAA (National Oceanic and Atmospheric Administration) has a climate analysis tool called "Climate at a Glance" (*http://www.ncdc.noaa.gov/cag/time-series/us*). This Web-based tool evaluates maximum, minimum, and average temperatures, precipitation amounts, heating degree days, cooling degree days and several drought indices. The data can be selected geographically on a local to global scale.

- Regional Climate Centers (*http://www.wrcc.dri.edu/rcc.html*) provide a variety of maps and tools to help understand and quantify historic climate data and trends.

Current Weather Forecasts

- National Weather Service Climate Prediction Center (*http://www.cpc.noaa.gov/*) provides 6-10 day forecasts up to one year.

Future Projections

- National Climate Assessment (*http://nca2014.globalchange.gov/downloads*) report for 2014 provides regional climate projections and impacts by economic sector (e.g. agriculture, forest).

- Intergovernmental Panel on Climate Change (IPCC) (*http://www.ipcc.ch/index.htm*) provides a variety of products regarding the science of climate change but also has reports on anticipated climate changes.

- cli-MATE (*http://mrcc.isws.illinois.edu/CLIMATE/*) is a tool that allows users the ability to graph raw climate data, show rankings, and view maps of a variety of temperature and precipitation data.

- The American Association of State Climatologists (*http://www.stateclimate.org/*) provides a list of individual state climatology offices. These local offices may offer additional insights into local climate trends.

- U.S. Drought Monitor (*http://droughtmonitor.unl.edu/*) provides reports on current drought status across the United States. This information may be useful for short-term drought management.

References

American Farm Bureau Federation. 2015. Fast Facts about Agriculture. *http://www.fb.org/index.php?fuseaction=newsroom.fastfacts accessed 06/01/2015*

Animal Agriculture in a Changing Climate extension project: *www.animalagclimatechange.org*

Busby, D., D. Loy. 1995. Heat Stress in Feedlot Cattle: Producer Survey Results. Iowa State University Leaflet R1348.

Extension Disaster Education Network: *http://eden.lsu.edu*

Hannam, P. 2013. NZ drought sends global milk prices soaring. The Land AU. March 2013.

Howitt, R., J. Azuara, D. Macewan, J. Lund, D. Sumner. Economic Analysis of the 2014 Drought for California Agriculture. *https://watershed.ucdavis.edu/files/content/news/Economic_Impact_of_the_2014_California_Water_Drought.pdf*

Howitt, R.E., J. Medellin-Azuara, D. MacEwan, J.R. Lund, and D.A. Sumner. (2014). Economic Analysis of the 2014 Drought for California Agriculture. Center for Watershed Sciences, University of California, Davis, California. 20p. Available at *http://watershed.ucdavis.edu*

National Climate Assessment: 2014 *http://nca2014.globalchange.gov/*

NOAA (National Oceanic and Atmospheric Administration) National Climate at a Glance: *http://www.ncdc.noaa.gov/cag/time-series/us*

St-Pierre, N.R., B. Cobanov, and G. Schnitkey. 2003. Economic losses from heat stress by U.S. livestock industries. J. Dairy Sci. 86:(E. Suppl.):E52-77.

Walthall, C.L., J. Hatfield, P. Backlund, L. Lengnick, E. Marshall, M. Walsh, S. Adkins, M. Aillery, E.A. Ainsworth, C. Ammann, C.J. Anderson, I. Bartomeus, L.H. Baumgard, F. Booker, B. Bradley, D.M. Blumenthal, J. Bunce, K. Burkey, S.M. Dabney, J.A. Delgado, J. Dukes, A. Funk, K. Garrett, M. Glenn, D.A. Grantz, D. Goodrich, S. Hu, R.C. Izaurralde, R.A.C. Jones, S-H. Kim, A.D.B. Leaky, K. Lewers, T.L. Mader, A. McClung, J. Morgan, D.J. Muth, M. Nearing, D.M. Oosterhuis, D. Ort, C. Parmesan, W.T. Pettigrew, W. Polley, R. Rader, C. Rice, M. Rivington, E. Rosskopf, W.A. Salas, L.E. Sollenberger, R. Srygley, C. Stöckle, E.S. Takle, D. Timlin, J.W. White, R. Winfree, L. Wright-Morton, L.H. Ziska. 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. 186 pages.

Zhorov, I. 2013. Why did South Dakota Snow Storm Kill so Many Cattle. National Geographic. Oct 22, 2013 online access.

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