

Through the Decade: Extreme Weather's Impact On Agriculture.
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Abstract

In the past decade, 78,000 people, on average, have perished every year due to extreme weather conditions. In addition to decimating the human population, extreme weather conditions have deeply affected agricultural production. The changing climates of the world in the last decade have led to many different extreme weather events, such as tornadoes, droughts, hurricanes, floods, and monsoons. These events have both detrimental and beneficial effects in agriculture in the United States of America, and such events have made it necessary for workers in the agricultural sector to alter their practices and plan around the new obstacles presented by the ever changing weather trends.

Flooding is extremely detrimental to 2 areas of agriculture—crop harvesting and livestock. Flooding can easily cause oxygen depletion, disease, and nitrogen loss in plants, and it can also negatively affect livestock by destroying animal housing. Floods also account for roughly a third of all natural catastrophes. Because of their recurring nature, floods present blatant trends that can be planned around.

The North American Monsoon, which affects the southwest area of the United States, causes floods, and thunderstorms, which result in hail and lightning caused field fires. People prepare for these by way of the multiple NCEP Prediction Centers to warn against floods, damaging winds, and hail. The southwest United States relies heavily on the rain for their irrigation agriculture and provides the rest of the United States with a majority of the crops, and livestock.

A tornado is a violently destructive storm with a revolving column of air coming in contact with and extending between a long, funnel-shaped cloud. Tornadoes are created by the moisture from their thunderstorms and the unpredictability that comes with the warming of spring and summer. Crops need this moisture and the variability of the temperature to grow, so the conditions for agricultural growth and tornadoes occur in the same regions.

Hurricanes can wipe out agricultural sectors along the Eastern Seaboard of the United States. Flooding, massive thunderstorms, extreme wind gusts, or flying debris caused by the storm can cause damage to agricultural infrastructure, livestock, and crops. Preventative measures can be taken to prevent extreme damage to agricultural sectors.

Drought is a natural reduction in the amount of precipitation over an extended period of time. It is common, and it impacts a great deal of agriculture. Crops especially need precipitation in order to survive. Drought is a recurring event in many areas of the world, and advances in science have helped farmers minimize the impact of drought.

Introduction

In the past decade, 78,000 people, on average, have perished every year due to extreme weather conditions. In addition to decimating the human population, these extreme weather conditions have deeply affected agricultural production. Agriculture is integral for the sustenance of the human race. It is impacted by many external forces; but climate change is at the forefront of the outlying factors that affect agriculture. The changing climates of the world in the last decade have led to an influx of a variety of extreme weather events. These events, such as tornadoes, droughts, hurricanes, floods, and monsoons, have been detrimental and beneficial effects in agriculture in the United States of America. Such events have made it necessary for workers in the agricultural sector to alter their practices and plan around the new obstacles presented by the ever changing weather trends. These extreme weather events profoundly impact the economic aspects of agricultural industry. Extreme weather events impact the heterogeneous agricultural sector of the United States of America differently depending upon the products produced in that geographic region.

Methods

We utilized an organic approach to begin our research. First, the research was divided up equally based on the extreme weather events most prevalent in the United States of America, the emphasis was placed on events that had a significant impact on the agricultural sector. The online database at the Virginia Tech library, Addison, was utilized to find the impact on agriculture. Keywords used in our searches were “extreme weather” and “weather events;” which were supplemented with other keywords pertaining to the topic of discussion. We then researched specific extreme weather events that occurred in the last decade (2000-2009). The search led us to online journals and books within the library that we could use to further our understanding of the topic. The same previous keywords were used once more in a Google Scholar search to explore the topic further. This was done by searching for definitions of extreme weather events, their effects on agriculture, specific examples of weather events that had a significant impact on the agricultural sector, and the preparation needed to preserve agricultural products during extreme weather occurrences.

Results and Discussion

The EU Floods Directive succinctly defines a flood as “a temporary covering by water of land not normally covered by water.” Essentially, a flood occurs when an expanse of land is inundated by water, usually (but not always) because of an influx of sustained rainfall or the rapid melting of snow. There are 5 main types of floods. These include: riverine, estuarine, coastal, catastrophic, and muddy (Twining). Riverine flooding is a long term event—it may last a week or more. Such flooding is often the result of meteorological and hydrological (essentially the distribution and effects of water on the earth’s surface) factors. This type of flooding can occur due to immediately explicit causes such as prolonged rainfall and rapid snowmelt. This flooding can also occur due to the environmental “leftovers” of previous meteorological events, such as saturated soil conditions from previous rainfall, high river flows present after previous rainfall, and silt buildup in rivers during previous storms that reduce the capacity of the river to carry water. Riverine flood types also include 2 sub-categories—slow kinds and fast kinds. Slow

kinds are characterized by rapid snow melt or sustained rainfall, while fast kinds include sudden releases of water (a dam breaking, etc.). Estuarine floods are caused by tidal surges (which are caused by high-velocity winds) (Twining). Coastal floods are caused by intense sea storms (Twining). Catastrophic floods are caused by unexpected events, such as dam breakage, earthquakes, or volcanic eruptions (Twining). A muddy flood can occur when runoff from crop lands accumulates to dangerous level (Twining). The runoff picks up moisture and sediment as it travels, and turns into a flood.

Throughout the duration of the past decade, there were 7 major floods. The 2000 Mozambique flood was caused by heavy sustained rainfall that lasted for 5 weeks. At least 800 people were killed, along with 20000 cattle. 1400 square kilometers of arable land was lost as well. Tropical Storm Allison hit the US in 2001, and brought catastrophic flooding to the lands of Texas. 23 people perished, and transportation systems that fueled the agriculture in that area were crippled for days. Similar damages and effects were seen in the 2002 European floods (which hit central Europe) and the 2002 Glasgow floods. The Boscastle flood of 2004 occurred in England, and decimated the pea crop for that season. It is estimated that 40 percent of the pea crop (which is an integral part of the economy in that area) was ruined. Flooding in Mumbai, India, in July 2005 left over 700 dead. Some areas went under 5 m of water. 80 percent of New Orleans was flooded throughout the duration of Hurricane Katrina in August 2005. The New Orleans agricultural sector took years to recover.

Flooding in the United States generally occurs in coastal areas, low-lying areas in the Midwest, and areas near rivers. Flooding in the Midwest poses serious risks to the agricultural sector, particularly where livestock is concerned. Considering that the Midwest is regarded as the “hub” of American livestock, flooding can severely alter farmer payout in a season. Coastal areas and areas near rivers are prime locations for growing crops because of how these areas have the most fertile soil. These areas are the biggest crop producing areas in the country, and as such, any sort of flooding is extremely devastating to the agricultural sector of the economy in the United States. Flooding is extremely detrimental to many facets of agriculture in the United States as well as other countries around the world. At the most basic level, floods damage crops and severely reduce farmer returns. The two areas of agriculture that floods most severely and directly affect are crop harvesting, and livestock.

Floods negatively affect the crops on a farm. Like humans, farm plants and crops need oxygen to live. Flooding can easily cause oxygen depletion, as water contains less oxygen than air (Mitchell). Other external factors that are intrinsically present during a flood can increase oxygen depletion further. The oxygen consumption of a plant is dictated by temperature (Mitchell). Warmer floodwaters cause faster depletion of dissolved oxygen and more crop damage and death. A more obvious detrimental effect of flooding is related to the duration of time that a plant is submerged underwater. The longer a plant is underwater, the longer it exists in less-than-ideal oxygen conditions, so more plant damage occurs. Water movement patterns are also key in determining plant and crop damage. Moving water usually carries oxygen that is in a more “dissolved” state (Mitchell). Water that is still or moving slower would, consequentially, have less dissolved oxygen. Knowing the effects of water movement patterns easily conveys the fact that moving water is better for crops, at least in terms of oxygen depletion. Of course, if water is moving too fast, plants and crops can be dislodged. The stage of the crops development also plays a key part in determining crop and plant damage. An aged plant is generally taller than

its younger counterparts. If the plant head is sticking out above the water (even by a little amount), it means that the plant has a better chance of obtaining oxygen from the air. Essentially, the worst case scenario for crops while flooding occurs is a long period of total warm-water submersion in still or stagnant water.

Crop damage can continue even after floodwaters recede—namely by way of nitrogen loss and disease. Flooding leads to weakened plant defenses even after the initial influx of water has subsided. The soil conditions present after the water has covered the ground are extremely conducive to the contraction of diseases (Twining). These plant diseases include root rot and stalk rot. If a farmer would like to stem the contraction of such diseases, he or she would have to purchase and apply fungicides. This would greatly increase production costs. Plants also need soil nitrogen for growth. Flooding can cause “loss of soil nitrogen because of enhanced denitrification during anaerobic soil conditions which persist during flooding” (Twining). Nitrogen can be reapplied to soil, but this would again increase production costs.

The physical damage that occurs due to flooding is perhaps the most severe. The most obvious effect of extreme flooding is the washing away and uprooting of crops and plants. Flooding can possibly entail fast traveling waters, and this can greatly damage plants. Fast traveling water can also move soil, which can further damage crops. Erosion could possibly wash the extremely fertile topsoil away, which would detrimentally impact farmer’s profits. Soil can also be displaced in great amounts, and often times such soil movements can smother existing crops.

Floods also negatively affect the livestock on a farm. One direct impact on livestock is the effect a flood has on animal housing. Many animals, such as pigs, require indoor housing and shelter. If a shelter is flooded, immediate evacuation is necessary. This requires a lot of manual labor on the farmer’s part, and sometimes, a farmer may not have another site to place the effected pigs in. Animals that graze outdoors are under the constant threat of drowning or being swept away. For smaller animals, such as piglets, cold flood water may cause hypothermia and lead to an increase in mortality. Small animals can also easily drown or be swept away. Many animals may be unnecessarily stressed during the ordeals of a flood, and they may die or fall sick that way. The flooding itself may also bring about a fresh wave of disease for farm animals. Floodwater contains many germs and contaminants (such as slurry), and animals that come into contact with this may fall sick. Diseases may perpetuate and permeate the farm society through infected drinking water or infected feed. Damp conditions are also conducive to the contraction of foot-rot, a hoof infection (especially in sheep).

Floods account for roughly a third of all natural catastrophes. Because of their recurring nature, floods present blatant trends that can be planned around. Farmer’s can monitor river and stream systems for sudden increases in capacity and water level. Tide cycles and trends can be kept track of in coastal areas. This could help in the prevention of flooding of inner bodies of water as a result of a sudden rise in tide in the ocean. Farmer’s can also simply pay attention to forecasts—floods can be prepared for if an incoming storm system is noticed quickly. Storm cycles are often recurring, especially in times like hurricane season, etc.

Hurricanes are a destructive force found in the Atlantic Ocean during the warmer months in the Northern Hemisphere, which can potentially affect the agricultural areas of the Eastern seaboard in the United States of America. Within the last decade 27 hurricanes have occurred in which their registered names were taken off the list of hurricane names because of the severity they inflicted upon the areas of impact (Names of notable hurricanes are retired). Hurricanes develop from tropical storms which gain strength causing the barometric pressure to drop and the formation of the eye to occur, in which clouds curve towards the center of the storm (Longshore). The hurricane has a cyclical motion in which the air fueling the storm is heated convectionally; leading to warmer air masses rising and cooler air masses descending. (Longshore) Tropical storms are not categorized into hurricanes until wind speeds are sustained at 64 kt or higher (Hurricane Basics). The hurricane is then categorized by the Saffir Simpson scale which rates the storm on a scale from one to five, five being the strongest type of hurricane (Hurricane Basics). Once the hurricane is formed the storm itself has no control whatsoever of its directionality which can lead it inland, causing the storm to lose its massive power (Longshore). Along coastline areas and islands the storm can wipe out entire agricultural sectors by flooding, massive thunderstorms, extreme wind gusts, or flying debris. Agricultural practices at sea, such as fisheries, are affected as well as inland practices.

Hurricanes can damage agriculture but in some areas they increase agriculture productivity. In semi-arid areas flooding caused by the hurricanes can increase water availability making that land less susceptible to dry seasons and ensuring better crop outputs and healthier livestock (Sivakumar et al, 2005).

Hurricanes are directly responsible for the destruction of agricultural sectors along coastline regions. Agricultural infrastructures can be damaged by hurricanes: canals, wells, and tanks can all be damaged by high storm winds, and flooding. A long term effect of a hurricane is the loss of soil fertility by salt water flooding agricultural land (Sivakumar et al, 2005). The water used for livestock and crop irrigation can be contaminated by salt water leading to dehydration and fatality of both livestock and crops. Mosquitoes will breed in flooded areas, standing water, leading to an increased amount of pests which may further disrupt the agriculture of the area leading to increased chances of disease.

The livestock, forestry, and fishing industries acquire less monetary losses than the cropping industry due to the high speed winds which can irreversibly damage a harvest (Sivakumar et al, 2005). Hurricane Isabel, a category 2 storm, created mass havoc in the agricultural sector of the East coast with 152 million dollars of damage. Cotton sustained 53 million dollars of damage, soybeans sustained 26 million dollars of damage, tobacco sustained 9 million dollars of damage, peanuts sustained 8 million dollars of damage, and corn sustained 6 million dollars of damage. 162,554 dollars were lost by chicken producers and 34 million dollars worth of damage occurred to agricultural structures (Yancy).

Hurricane Katrina caused irreparable damages to the crop harvest along the eastern seaboard with a total of 900 million dollars in losses. 9% of Louisiana's sugar cane production was lost during the hurricane. 30 million dollars were lost in the livestock production industry and damage came to poultry producers who lost eggs, birds, and their facilities. The cattle industry was hit especially hard, 3 million dollars of milk was discarded due to the loss of electricity during the high wind gusts and 10,000 cattle were lost (USDA: Katrina crop damage at \$900 million).

Florida's farms went through a whirlwind of destruction with Hurricane Wilma. The state of Florida lost 1 billion dollars in agriculture because the storm came during full maturity of crops. 75 percent of the grapefruit crop was knocked to the ground, and was deemed not sellable. Crops grown in greenhouses were damaged as the greenhouses were without power for several days (Hurricane Wilma hits Florida farms).

Although forestry practices do not acquire as many monetary losses hurricanes can be both beneficial and detrimental to the forestry industry. Pecan trees can be positively affected by hurricanes. Arthropods are suppressed by the storm leading to less use of pesticides and better pecan output. Also, hurricanes give needed rain to the trees and help to reduce stress upon the pecan trees as they start kernel filling. Pecan tree roots may be uprooted and have limb damage if they are along the coastline during a hurricane's landfall (Wood et al. 2001). Trees that have lost or damaged major limbs will lose yield potential for up to five years. If damage occurs to the heartwood of the tree the trees may never reach their potential yield harvest again (Reighard et al, 2001). Crop harvests may not or will not occur the following year after a storm if they are defoliated before early November and will bear a heavy, low quality crop the second season. Pecan fruit may not survive the storm, as the winds could possibly knock the fruit off the tree and flooding may cause the fruit to be lost. Diseases such as scab can be spread more easily because of the extreme weather during a hurricane and the use of a poorly timed fungicide prevention which will prevent output recovery after a hurricane (Wood et al, 2001). Peach trees are very negatively affected by hurricanes. Nonbearing peach trees can be uprooted or twisted leading to 50% or more of the trees dying. Flooding can cause shallow rooted peach trees to have heart rots leading to the death of the tree (Reighard et al, 2001).

Forestry sectors can prepare for a hurricane by removing logs that could potentially obstruct roads and other means of transportation. (Protz.) Preventative measures can be taken before a hurricane hits an agricultural area. Peach trees can be protected from severe damage by hurricanes by agricultural workers improving drainage around the trees, shearing extensive branching off young trees, planting windbreak species suitable for the area, and maintaining healthy and deep rooted trees (Reighard et al, 2001). Pecan trees can be cared for by improving drainage in the surrounding areas and reducing pecan tree canopies.

In preparation for a hurricane agricultural workers can prevent their livestock from injury and possible death by taking the livestock to higher ground to avoid flood waters. The livestock should also be supplied with at least a week's supply of feed and water (Protz). Crops can be potentially saved from the destructive powers of a hurricane. Hurricanes normally approach around harvesting season for crops; agricultural workers can harvest the crops beforehand if they are aware of a storm heading in their general vicinity (Protz). Pesticides and other various chemicals should be placed in non permeable containers to prevent the poisoning of the water supply. All agricultural sectors should ensure that farm records are kept in a non permeable container that can withstand high winds and flood waters that are a direct result of the hurricane. Workers should be kept on standby for when the storm reaches landfall and equipment should be secured and checked for working condition (Protz).

A tornado is a violently destructive storm with a revolving column of air coming in contact with and extending between a long, funnel-shaped cloud and the surface of the earth. Tornadoes are created from the polar air that is brought in by Canada, the tropical air from the Gulf of Mexico, and the dry air from the Southwest that collide in the Midwest and produce the

thunderstorms which cause the tornadoes. There are more than one thousand tornadoes that occur each year in the United States alone. Tornadoes are highly unpredictable in that they can take place one at a time or come in groups, and a tornado's length, width, speed, direction, and time fluctuate significantly. The wind speed of a tornado can be more than 200 miles per hour and in severe cases reach up to 300 miles per hour. They can be fifty yards or even a mile wide, and can stay in contact with the ground for a few seconds or for more than an hour. Tornadoes are categorized on a scale of one to five using the Enhanced Fujita Scale and their wind speeds are determined after the storm is over according to the damage they produce (The Weather Channel, 1995).

Most tornadoes occur in agricultural areas. Tornadoes are created by the moisture from their thunderstorms and the unpredictability that comes with the warming of spring and summer. Crops need this moisture and the variability of the temperature to grow, so the conditions for agricultural growth and tornadoes occur in the same regions (Fujita, 2000). Since tornadoes can appear unexpectedly with hardly any warning they have the potential to destroy an area quickly. This destruction can affect agriculture by polluting water and ruining crops, livestock, and other farm property (U.S. Environmental Protection Agency, 2008).

Texas is a major agricultural area contributing almost eighteen billion dollars in agricultural output annually and roughly seventy-seven percent of all of the land in Texas is farmland with about 229,000 farms and ranches (Texas AgriLife Extension Service, 2004). However, producers are at a high risk for many disastrous weather events like tornadoes. There are approximately 153 tornadoes that occur each year in Texas. On May 15, 2003, there was a record of 23 tornadoes reported over an eight hour period that occurred in the Texas and Oklahoma Panhandles. The strongest tornado was in Wheeler County, TX and traveled ten miles before it crossed into Oklahoma. This tornado reached a two on the Fujita Scale and it had a maximum width of one mile across for five miles (AMA Webmaster, 2009). Another example of a tornado in an agricultural area was in Windsor, CO on May 23, 2008. Windsor, CO is 45 miles from Denver with a population of about 18,670 and it is an intensely agricultural area. Windsor was the town that was hit the worst by this span of tornadoes (Estes, 2008). A more recent storm occurred on May 10, 2010 in the southern Plains of Oklahoma (Talley, 2010). Oklahoma, like Texas, is prone to many destructive weather events such as large hail, damaging winds, and tornadoes. This tornado left five people dead and at least 58 injured (Talley, 2010).

Agricultural producers must be aware of the effect a tornado can have on themselves, their family, and the impact on their crops, livestock, machinery and food and water supplies. Farmers must also be ready for the economic down side that is connected to loss of life, property, and income. It is a difficult challenge to prepare for tornadoes because they can arrive suddenly, and with tornadoes can also come flash floods and hail. However, there are some ways farmers can plan for this disaster ahead of time. Farmers can build shelters for livestock and have a plan ready in case of an emergency. Farmers can insure their farms against extreme weather such as tornadoes for the replacement of damaged or ruined materials and machinery, repair work for

recovery, lost production, and relocation. Farmers must also take inventory of livestock, property, and hazardous substances. During a tornado, livestock can be killed, lost, or stolen so farmers should attach ID tags to their animals and a description of that animal. For machinery they should keep an updated list of their equipment that includes the model number and the make. Lastly, farmers should maintain a list of fuels, medicines, chemicals, fertilizers, and pesticides. If a tornado warning has occurred farmers can move hay, machinery, fuels, pesticides, fertilizers, and other chemicals into a safe, secure area, secure loose items like machinery parts and tool, and turn off electrical power to machines, barns, and structures that could become damaged. The livestock will often seek shelter in an emergency situation like this. These steps will make the disaster recovery for tornadoes much safer because there is less of a chance of displaced hazardous chemicals mixing together and less of a chance that livestock might find them as well (Texas AgriLife Extension Service, 2004). This may not fully protect the farm and livestock completely, but these precautions increase the probability that the farm will be kept safe throughout this disaster.

A monsoon is a system of winds that bring in moisture, heavy rainfall, and thunderstorms as a result of the shift in winds. There are surface winds flowing from one quarter in summer and again from a different quarter in the winter(Ramage, 1971)(Stellar, 2009). The word monsoon is somewhat of a controversial one. There are debates over the etymology of the word but a common consensus is that the word's base meaning has to do with seasonality(Ramage, 1971)(NOAA, 2004). This seasonality is common with monsoons, and this base of the word becomes clear because of the ease and accuracy with which farmers are able to prepare for and predict the monsoon season. The monsoon season also starts and ends within a few days of the previous year's monsoon. On average, the monsoon season starts early in June and ends in the late September in the South Asian areas, but in the North American region the season is slightly different. During May and June, heavy rainfall begins in Mexico and moves northward making the starting dates for monsoon season in North America range from June to July (NOAA, 2004).

The monsoon is harder to predict because it arrives abruptly. The days in that area go from hot and dry days to relatively cool, and rainy ones (NOAA, 2004). And though it occurs around the same time, the exact day of when it will occur is not the same making it potentially dangerous to the inhabitants of that area. Hurricanes, floods, and droughts that have previously occurred in that area normally influence the arrival of the monsoons. This event is also sporadic in the weather events occurring during the monsoon. Some of the most prevalent extreme events that occur include floods and lightning storms. Flash floods are the number two weather related killer in the United States and especially in the Southwest they can happen very suddenly and harshly. The NOAA has a radio station, which informs the public about the current weather related news (NOAA, 2004). The people who live in this area are recommended to move to higher ground and to avoid any flooded areas so as to not get swept away by the current. The lightning and thunderstorms are also severe in that region. There are on average tens of thousands lightning strikes per evening, which can lead to field fires, and they can also cause crop-damaging hail (NOAA, 2004). Additionally it is recommended that the inhabitants follow the 30/30 rule. One should wait 30 seconds to hear thunder after one sees lightning, and if one cannot count to 30, do not go outside. The people should also wait 30 minutes after hearing the

last clap of thunder before going outside. These storms cover a larger area than the rest of the United States therefore they are more disastrous. The NCEP Storm Prediction Center alerts the Southwest United States of incoming damaging winds and hail. And the NCEP Hydrometeorological Prediction Center watches for floods for the farmers and others to prepare against the elements (NOAA, 2004).

Unlike most extreme weather events, monsoons are considered to be beneficial for the agriculture industry, especially in places such as India and Nepal, the heavy rainfall, which results from monsoons, generates the livelihoods of the farmers (Oracle Education Foundation, 2009)(Monsoon Season, 2009). Based on this need for water these people have come to almost solely rely on the monsoons for their crops and have been able to, find a pattern within the monsoons appearances (Monsoon Season, 2009). In the United States, a similar phenomenon occurs. Although there is a seasonal monsoon circulation in the North American region, the shift in winds are less pronounced as they are in areas such as Australia, India, and Southeast Asia. This North American Monsoon affects mainly the Southwest area of the United States such as Arizona and Southern California. Despite the fact that the southwest is not affected as extremely as other areas of the world, it still receives half of its annual rainfall from the monsoon making the monsoon a widely anticipated event. The monsoon provides water to multiple rivers such as the Rio Grande and the Rio Bravo(Arizona Board of Regents, 2010). This water availability in turn affects the flora and fauna in the area and the beginning and the end of the fire season. Without this annual precipitation, many of the crops in Arizona and Southern California would perish.

Agriculture is a \$9.2 billion industry in the state of Arizona. The state has a total land area of 72,730,000 acres. Out of that area 36 percent is the total farmland, with irrigated crops on five percent of those acres and pasture for animals on 90 percent of those acres (USDA, 2010). Irrigation is a large part of the farming in Arizona and Southern California and Arizona has one of the most efficient irrigation systems in the world. It is necessary for the irrigation to be a part of the agriculture of these states because of the dry, arid and semi-arid land (USDA, 2010). The southern half of the state is mainly desert and the average temperature for southern Arizona ranges from lows of 30 degrees Fahrenheit in the winter to over 100 degrees Fahrenheit in the summer, however it is good for year round crop growth in irrigated areas. Arizona ranks second nationally in its' production of cantaloupe and honeydew melons, head and leaf lettuce, spinach, broccoli, cauliflower and lemons. The top agricultural crop exports are vegetables, cotton and cotton linters, and fruits and seeds. Aside from crops, cattle, and dairy goods are some of Arizona's most valuable farm products, with cattle and calves representing 25 percent of total farm receipts and dairy products representing 17 percent (USDA, 2010). "Droughts are not uncommon in Southern California, and all crops are irrigated. The main temperate fruit and nut crops grown commercially in this region are apple, macadamia, olive, peach, persimmon, and English walnut (Vossen, 2010)." It is apparent that much of the economy, not only in these areas, but also in the rest of the United States rely on the products of the agriculture business and without the water that monsoons regularly bring, this business would not exist.

Drought is a natural reduction in the amount of precipitation over an extended period of time. There are many different definitions of drought for the ways it impacts people. In this case, an agricultural drought is brought about when there is insufficient moisture for

average crop or range production. Farmers can't meet the requirement to feed their families or fulfill their commitments. This condition may even happen in average rainfall due to soil conditions or agricultural techniques. Soils with a low water-holding capacity are more prone to drought. Seasonal droughts occur in climates that have well defined annual rainy and dry seasons. Drought has many negative impacts on agriculture.

A drought is one of the worst natural disasters because it is able to cover wide areas and continue for extended periods of time. Droughts not only affect the direct area, but also the nearby cities that rely on that food and service income. Fourteen percent of the United States is affected by severe to extreme drought annually. Last year, Texas experienced their worst drought in over a century. Texas is one of the nation's top providers in cotton and cattle. The dry pastures could not support that many cattle and many farmers were forced to sell. Federal aid is supplied to the farmers from a \$290 billion farm bill passed by Congress in 2008. Ten years ago, the United States was hit by an intense heat wave and drought. The east coast was hit the hardest and suffered a great loss in agriculture.

“According to NOAA , the USDA estimates that the drought could cost eastern farmers as much as \$1.1 billion in lost income. In addition, wildfires had developed in many parts of the western U.S. by late summer, and short-term moisture deficits were plaguing much of the southern Plains and Southeast. By early September, the remnants of Hurricane Dennis brought much-needed rain to parts of the mid-Atlantic and Northeast states.” 2000

The three characteristics that differentiate one drought from another are intensity, duration, and special extent. Droughts have an immediate effect on the recharge of soil resulting in the reduction of irrigation potential. In prolonged droughts, farmers may have to abandon their farms in search for work in the cities. Sometimes farmers attempt at sowing seeds repeatedly, this results in a shortage of seed reserves. During a prolonged drought there is sometimes the problem of food shortages for both humans and livestock. Farmers may also be hit with the indirect impact of the loss of potential production and disturbed flow of goods and services. Drought also causes new land quality problems. The lack of rainfall makes the land more vulnerable to erosion and desertification. The constant growth of the human population causes the demand for water to grow, while the supply remains the same.

Drought is a recurring phenomenon that cannot be avoided. It is best to be prepared for the results. The impacts of droughts may be minimized when the proper mitigation plans are applied, including the early warning, the risk assessment, and the evaluation of the process to be used. The focus in mitigation should be to manage rangelands, develop water resource programs, help with animal husbandry activities, and improve agriculture through modifying cropping patterns and introducing drought-resistant crops. In the United States, there has been a progress in drought preparedness due to the progress in technology that can predict oncoming droughts. There are two ways to predict an oncoming drought; analyzing past statistics of climatic records and by using computer models of the climate system to form statistics from explicit predictions of weather conditions. This extreme weather inflicts much pain and stress on agriculture and society. In the United States, the Corn Belt spreads North and West, but it still has its limits to the west because of drought. Since 2001, maize, a tall annual cereal grass bearing kernels on large ears, has been bred to be drought tolerant with many screenings. The hybrid maize has proved a higher crop yield in the west and will be supplied when available. In order to prepare for drought farmers may evaluate types of irrigation systems, take water from

deep aquifers instead of surface water, use conservative practices, raise animals that consume less water, and rotate crops in ways that increase the amount of water that enters the soil.

Drought is one of the most devastating examples of weather in nature. This act of nature damages landscapes and diminishes crop productivity. Farmers and scientists today still struggle with the impacts of severe droughts. Droughts are usually overlooked beside storms and other disasters, but in reality they catastrophic to the agricultural community and its counterparts.

Summary

Climate change has increased the amount of extreme weather conditions present in the United States; this in turn has affected American agriculture. Conditions such as floods, hurricanes, tornadoes, monsoons, and droughts have all affected agriculture both beneficially and detrimentally. These weather occurrences can damage agricultural infrastructure, contaminate water, cause widespread crop failures, cause livestock fatalities, and cause disease and pests to spread rapidly. Beneficial aspects of extreme weather, with the exception of drought, are that they bring much needed water to water scarce areas of agriculture; allowing for better crop and livestock production. Preventive measures can be taken against the weather by herding livestock to safe ground, insuring that there is a plentiful supply of fresh water and feed stuff, and keeping extra workers on hand. Agricultural workers must adapt to the changing environmental conditions in order to ensure that their livelihood is not destroyed.

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