Economic Impacts of Climate Change on Illinois

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CIER
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INTRODUCTION

Policymakers across the country are now seeking solutions to curb greenhouse gas emissions and to help us adapt to the impending impacts triggered by past emissions. The debate to date has primarily focused on the perceived costs of alternative solutions, yet there can also be significant costs of inaction. Climate change will affect our water, energy, transportation, and public health systems, as well as state economies as climate change impact a wide range of important economic sectors from agriculture to manufacturing to tourism. This report, part of a series of state studies, highlights the economic impacts of climate change in Illinois and provides examples of additional ripple effects such as reduced spending in other sectors and resulting losses of jobs, wages, and even tax revenues.

A Primer on Climate Change

Earth's climate is regulated, in part, by the presence of gases and particles in the atmosphere which are penetrated by short-wave radiation from the sun and which trap the longer wave radiation that is reflecting back from Earth. Collectively, those gases are referred to as greenhouse gases (GHGs) because they can trap radiation on Earth in a manner analogous to that of the glass of a greenhouse and have a warming effect on the globe. Among the other most notable GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). Their sources include fossil fuel combustion, agriculture, and industrial processes.

Each GHG has a different atmospheric concentration, mean residence time in the atmosphere, and different chemical and physical properties. As a consequence, each GHG has a different ability to upset the balance between incoming solar radiation and outgoing long-wave radiation. This ability to influence Earth's radiative budget is known as climate forcing. Climate forcing varies across chemical species in the atmosphere. Spatial patterns of radiative forcing are relatively uniform for CO_2, CH_4, N_2O and CFCs because these gases are relatively long-lived and as a consequence become more evenly distributed in the atmosphere.

Steep increases in atmospheric GHG concentrations have occurred since the industrial revolution (Figure 1). Those increases are unprecedented in Earth's history. As a result of higher GHG concentrations, global average surface temperature has risen by about 0.6°C over the twentieth century, with 10 of the last 12 years likely the warmest in the instrumental record since 1861 (IPCC 2007).

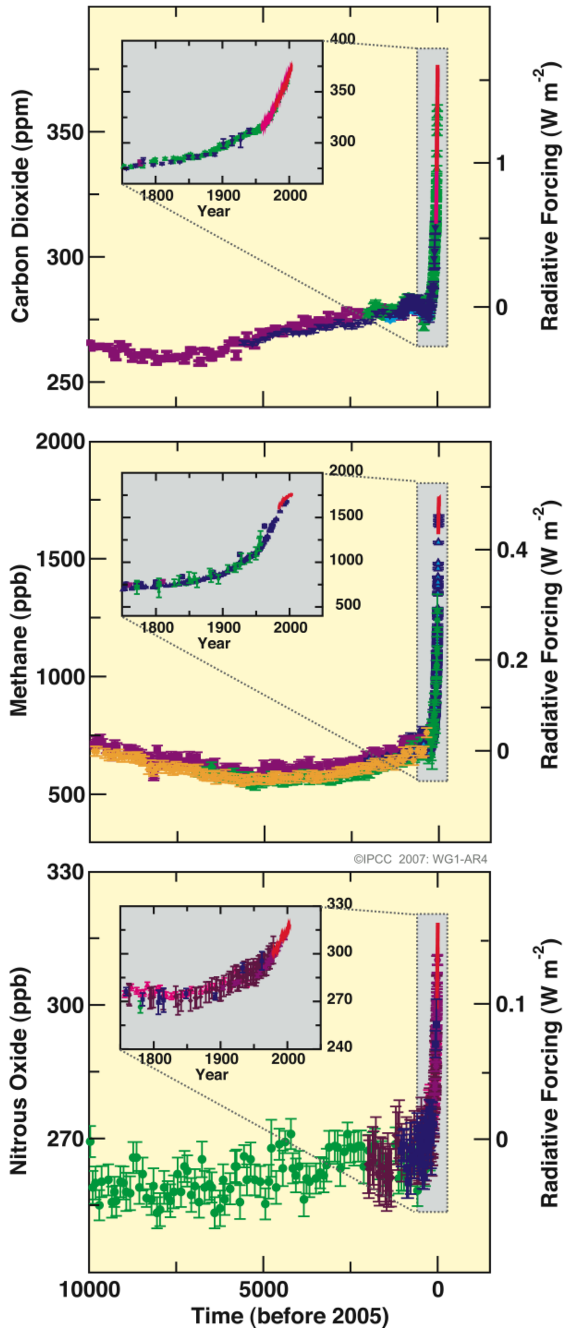

Figure 1: Atmospheric Concentrations of Carbon Dioxide, Methane and Nitrous Oxide (Source: IPCC 2007)

A change in average temperatures may serve as a useful indicator of changes in climate (Figure 2), but it is only one of many ramifications of higher GHG concentrations. Since disruption of Earth's energy balance is neither seasonally nor geographically uniform, effects of climate disruption vary across space as well as time. For example, there has been a widespread retreat of mountain glaciers during the twentieth century. Scientific evidence also suggests that there has been a 40 percent decrease in Arctic sea ice thickness during late summer to early autumn in recent decades and considerably slower decline in winter sea ice thickness. The extent of Northern Hemisphere spring and summer ice sheets has decreased by about 10 to 15 percent since the 1950s (IPCC 2007).

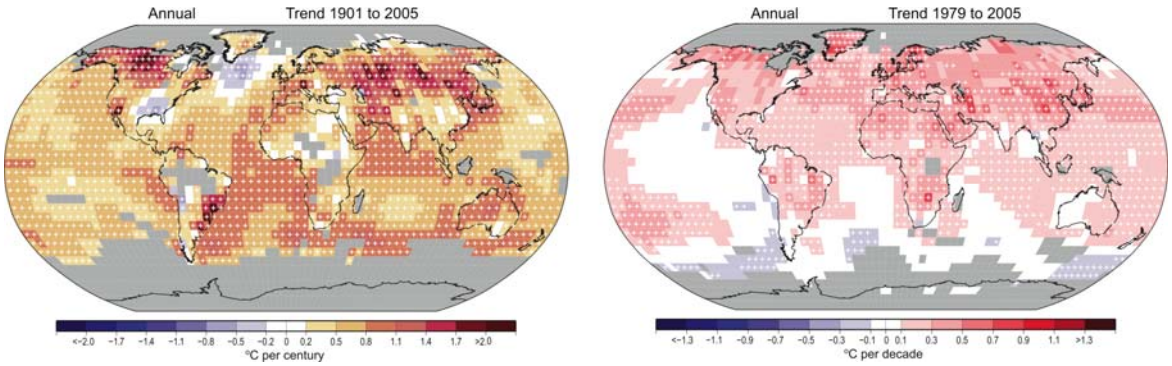

Figure 2: Annual Temperature Trends (Source: IPCC 2007)

The net loss of snow and ice cover, combined with an increase in ocean temperatures and thermal expansion of the water mass in oceans, has resulted in a rise of global average sea level between 0.1 and 0.2 meters during the twentieth century, which is considerably higher than the average rate during the last several millennia (Barnett 1984; Douglas 2001; IPCC 2001).

Changes in heat fluxes through the atmosphere and oceans, combined with changes in reflectivity of the earth's surface and an altered composition of may result in altered frequency and severity of climate extremes around the globe (Easterling, et al. 2000; Mehl, et al. 2000). For example, it is likely that there has been a 2 to 4 percent increase in the frequency of heavy precipitation events in the mid and high latitudes of the Northern Hemisphere over the latter half of the twentieth century, while in some regions, such as Asia and Africa, the frequency and intensity of droughts have increased in recent decades (IPCC 2001). Furthermore, the timing and magnitude of snowfall and snowmelt may be significantly affected (Frederick and Gleick 1999), influencing among other things, erosion, water quality and agricultural productivity. And since evaporation increases exponentially with water temperature, global climate change-induced sea surface temperature increases are likely to result in increased frequency and intensity of hurricanes and increased size of the regions affected.

Impacts of Climate Change Throughout the US

This study on the economic impacts of climate change in the State of Illinois is part of a series of state-focused studies to help inform the challenging decisions policymakers now face. It builds on a prior assessment by the Center for Integrative Environmental Research, US Economic Impacts of Climate Change and the Costs of Inaction, which concluded that throughout the United States, individuals and communities depend on sectors and systems that are expected to be greatly affected by the impacts of continued climate change.

- The **agricultural sector** is likely to experience uneven impacts throughout the country. Initial economic gains from altered growing conditions will likely be lost as temperatures continue to rise. Regional droughts, water shortages, as well as excess precipitation, and spread of pest and diseases will negatively impact agriculture in most regions.

- Storms and sea level rise threaten extensive **coastal infrastructure –** including transportation networks, coastal developments, and water and energy supply systems.

- Current **energy** supply and demand equilibria will be disrupted as electricity consumption climbs when demand grows in peak summer months. At the same time, delivering adequate supply of electricity may become more expensive because of extreme weather events.

- Increased incidence of asthma, heat-related diseases, and other respiratory ailments may result from climate change, affecting **human health** and well-being.

- More frequent and severe **forest fires** are expected, putting ecosystems and human settlements at peril.

- The reliability of **water supply networks** may be compromised, influencing agricultural production, as well as availability of water for household and industrial uses.

As science continues to bring clarity to present and future global climate change, policymakers are beginning to respond and propose policies that aim to curb greenhouse gas emissions and to help us adapt to the impending impacts triggered by past emissions.

While climate impacts will vary on a regional scale, it is at the state and local levels where critical policy and investment decisions are made for the very systems most likely to be affected by climate change – water, energy, transportation and public health systems, as well as important economic sectors such as agriculture, fisheries, forestry, manufacturing, and tourism. Yet, much of the focus, to date, has been on the perceived high cost of reducing greenhouse gas emissions. The costs of inaction are frequently neglected and typically not calculated. These costs include such expenses as rebuilding or preparing infrastructure to meet new realities and the ripple economic impacts on the state's households, the agricultural, manufacturing, commercial and public service sectors.

The conclusions from our nation-wide study highlight the need for increased understanding of the economic impacts of climate change at the state, local and sector level:

- Economic impacts of climate change will occur throughout the country.
- Economic impacts will be unevenly distributed across regions and within the economy and society.
- Negative climate impacts will outweigh benefits for most sectors that provide essential goods and services to society.
- Climate change impacts will place immense strains on public sector budgets.

- Secondary effects of climate impacts can include higher prices, reduced income and job losses.

Methodology

This report identifies key economic sectors in Illinois which are likely affected by climate change, and the main impacts to be expected for these sectors. The report provides examples of the direct economic impacts that could be experienced in the state and presents calculations of indirect effects that are triggered as impacts on individual sectors in the economy ripple through to affect others.

The study reviews and analyzes existing studies such as the 2000 Global Change Research Program National Assessment of the Potential Consequences of Climate Variability and Change which identifies potential regional impacts. Additional regional, state and local studies are used to expand on this work, as well as new calculations derived from federal, state and industry data sources. The economic data is then related to predicted impacts of climate change provided from climate models. To standardize the results, all of the figures used in this report have been converted to 2007 dollars (Inflation Calculator 2008).

Since the early 1990s, and especially during the 21st century, significant progress has been made in understanding the impacts of climate change at national, regional, and local scales. The Canadian and Hadley climate change models are cited most frequently and we look first to these, yet there are many other valuable models used by some of the specialized studies we cite in this report.

In addition to looking at data that illustrates the direct economic impacts of climate change, the report also provides examples of the often overlooked ripple economic effects on other sectors and the state economy. To calculate these, we employed a modified IMPLAN™ model from the Regional Economic Studies Institute (RESI) of Towson University. This is a standard input/output model and the primary tool used by economists to measure the total economic impact by calculating spin-off impacts (indirect and induced impacts) based upon the direct impacts which are inputted into the model. Direct impacts are those impacts (jobs and output) generated directly by the project. Indirect economic impacts occur as the project (or business owners) purchase local goods and services. Both direct and indirect job creation increases area household income and results in increased local spending on the part of area households. The jobs, wages, output and tax revenues created by increased household spending are referred to as induced economic impacts.

After reviewing climate and economic information that is currently available, the study identifies specific data gaps and research needs for further understanding of the significant economic impacts. There is no definitive total cost of inaction. Given the diversity in approaches among existing economic studies and the complexity of climate-induced challenges faced by society, there is a real need for a consistent methodology that enables more complete estimates of impacts and adaptation costs. The report closes with basic recommendations and concluding lessons learned from this series of state-level studies.

Not all environmentally induced impacts on infrastructures, economy, society and ecosystems reported here can be directly or unequivocally related to climate change. However, historical as well as modeled future environmental conditions are consistent with a world experiencing changing climate. Models illustrate what may happen if we do not act now to effectively address climate change and if adaptation efforts are inadequate. Estimates of the costs of adapting environmental and infrastructure goods and services to climate change can provide insight into the very real costs of inaction, or conversely, the benefits of maintaining and protecting societal goods and services through effective policies that avoid the most severe climate impacts. Since it is typically at the sectoral and local levels where those costs are borne and benefits are received, cost estimates can provide powerful means for galvanizing the discussion about climate change policy and investment decision-making.

These cost estimates may understate impacts on the economy and society to the extent that they simply cover what can be readily captured in monetary terms, and to the extent that they are calculated for the more likely future climate conditions rather than less likely but potentially very severe and abrupt changes. The broader impacts on the social fabric, long-term economic competitiveness of the state nationally and internationally, changes in environmental quality and quality of life largely are outside the purview of the analysis, yet likely not trivial at all. Together, the monetary and non-monetary, direct, indirect and induced costs on society and the economy provide a strong basis on which to justify actions to mitigate and adapt to climate change.

CLIMATE CHANGE IN ILLINOIS

Continued climate change impacts in Illinois are projected to result in higher temperatures and more frequent precipitation. With the manufacturing sector comprising a large portion of the economic activity in the state, a major outcome of climate change will be varying water levels throughout an important shipping route for the manufacturing sector – the Great Lakes-St. Lawrence Seaway. Changing water levels in the Great Lakes, as well as in other aquifers, rivers, and lakes, will impact both housing and transportation infrastructure and affect the agricultural sector. There are likely to be human health impacts, as well.

Historic Perspective

According to the US Global Change Research Program report, the Great Lakes region has warmed by an average of 4°F over the last century (Easterling et al 2001). Another indicator of the warming trend in Illinois is the observed increase in the change from average temperatures, as is illustrated in Figure 3 for the month of August over the last four decades (NOAA 2007).

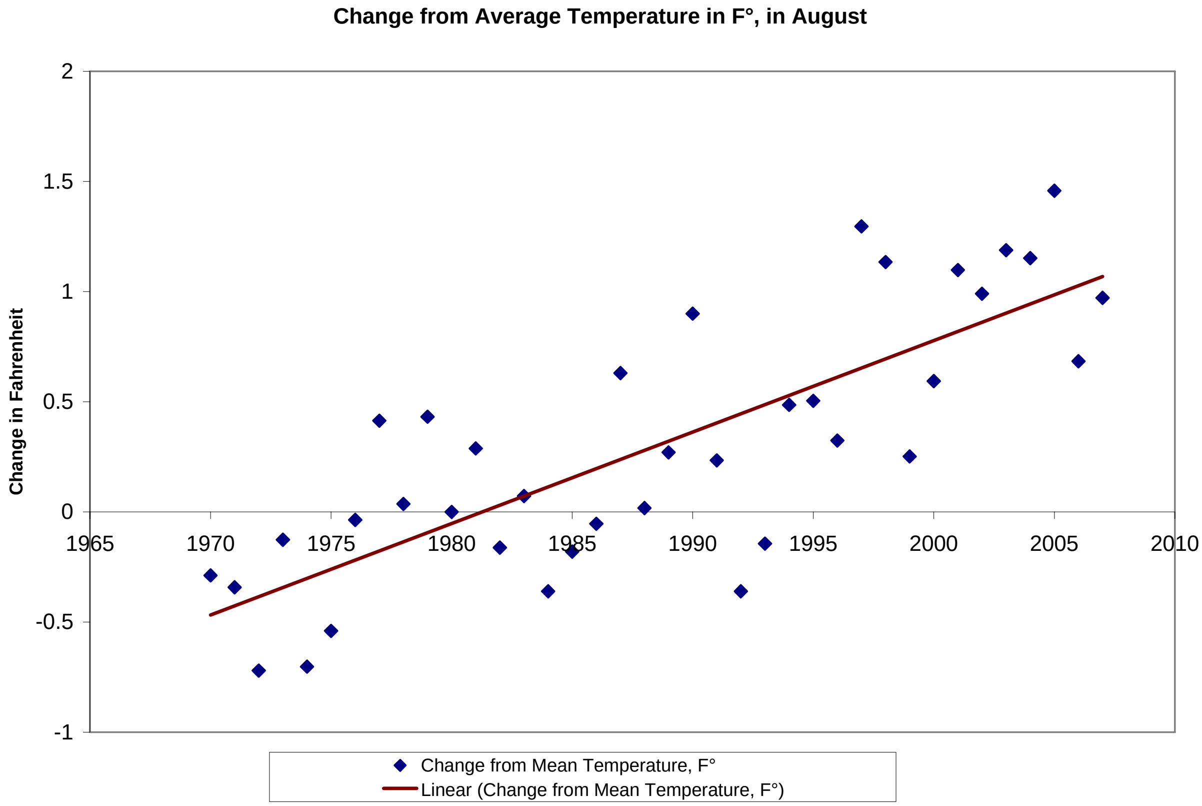

Figure 3: Illinois Change from Average Temperature in August (Source: NOAA 2007)

Additionally, annual precipitation has risen by around 20 percent in the region over the 20th century (Easterling et al 2001). Higher temperatures, however, have increased evaporation rates—which more than counteract the extra precipitation—resulting in lower water levels in Lake Michigan and the other Great Lakes. According to Canada's Department of Environment, Environment Canada, Lake Michigan's water levels in January 2008 were nearly 12 inches below its levels in January 2007 and 24.4 inches below the monthly average between 1918-2006 (Environment Canada 2008). Although there is no way to determine if they are linked to climate change, researchers at the National Atmospheric and Oceanic Administration state that the correlation of a warming climate along with decreased water levels may make the link plausible and state that planning for lower water levels in the coming century might be prudent (Sellinger 2008).

Climate Outlook

The climate outlook for the Midwest includes a continued warming trend with temperatures increasing by 5-10°F by the end of the 21st century. The largest change is expected to be in the average minimum daily temperatures, although extreme temperature occurrences are also likely to rise. For example, Chicago currently experiences three consecutive days with night temperatures above 80°F and day temperatures over 100°F once every 50 years. This pattern is predicted to occur on average once every 10 years until 2030s and afterwards every other year, as climate change impacts continue to be felt.

The length of the snow season (the number of days with snow cover) is expected to decrease by 50 percent, although overall annual precipitation events are forecast to increase from 20 to 40 percent in the Midwest. Despite the projected increases in precipitation, higher temperatures will raise evaporation rates resulting in lower water levels in the Great Lakes. In fact, throughout the century, the Lakes may experience a water level drop of up to 5 feet (Easterling et al 2001).

MAJOR ECONOMIC IMPACTS

Shipping

Manufacturing accounts for nearly 14 percent of Illinois' Gross State Product (BLS 2002) employing over 680,000 workers in 2006 (IDES 2007). The US Department of Commerce estimates Illinois' manufacturing sector contributing over $105 billion in annual value added productivity with a gross output of $71 billion (US Dept of Commerce 2005). Water transportation provides an efficient and cheap shipping option for the state's manufacturers. According to the US Army Corps of Engineers, Illinois shipped nearly 123 million tons of goods and materials via water routes in 2001 (US Army Corps of Engineers 2001). The water transportation industry directly employs over 2,000 people (BLS 2002), with many of the shipments going through the Great Lakes-St. Lawrence Seaway route, and contributing to over $23 million of Illinois' Gross State Product (BEA 2003).

If water levels continue to drop along the route, expensive dredging of channels will be necessary. In fact, dredging along the entire Great Lakes-St. Lawrence shipping route would cost from $92-154 million annually by 2030 under a climate change scenario with water levels dropping by 1.5-3 feet (Great Lakes Regional Assessment Group 2000).

Besides the Great Lakes-St. Lawrence route traffic, Illinois is the 8th state in the union in its miles of inland waterways with commercial cargo traffic with 1,095 miles, not counting channels in the Great Lakes[1]. These routes may be affected with increasing flood risk.

Infrastructure

The greatest risk to infrastructure in Illinois stems from the projected increase in heavy precipitation events. In fact, flooding is the most economically damaging peril in the state. Since 1983, Illinois has suffered over $287 million in annual damages from floods. Insurance Information Institute reported that insured catastrophe losses were $272 million in 2007 in Illinois – ranking the state 5th in the nation (III 2007). Moreover, flood damages have been following an upward trend in recent years (Illinois State Water Survey 2003). For example, flood losses incurred between 1985-1999 accounted for 74 percent of losses throughout the 1955-1999 period (Illinois State Water Survey 2003).

[1] St. Lawrence Seaways waters and other waterways connecting the Great Lakes are included.

This is partially a result of higher real estate prices in the state, particularly in the Chicago area.

A related but unique issue is the recent popularity of lakefront housing prices in and around Chicago. In fact, lakefront housing prices were on average 10 percent higher than prices elsewhere in Chicago from 1999-2004, and average prices have increased by 55 percent during this period. In fact, total value of house sales on the lakefront within those five years was over $14.3 billion ($s current at the time) and accounted for over a third of housing sales value in the city (Appraisal Research Counselors 2005).

These lakefront houses may be impacted in two ways. With water levels dropping in Lake Michigan, the property value may be diminished. Another impact may be from floods stemming from heavy precipitation events. Depending on the water levels in the Lake and stormwater management practices, the floods may cause large economic losses. Direct premiums written in federal flood insurance topped $26.3 million in 2006 (III 2006).

Flooding may occur more frequently as precipitation levels increase. For example, a study looking at the Mid-Atlantic region found that 1 percent increase in annual precipitation results in a 2.8 percent increase in economic damages, as measured by previous insurance loss data (Choi and Fisher 2003). Precipitation levels largely determine streamflow. According to the Illinois State Water Survey, a 10 percent change in precipitation produces a 20 to 25 percent change in streamflow ((Wistanley and Wendland 2007), indicating that with projected increasing levels in precipitation, streamflow may become heavy and prone to flooding. The overall annual economic impact on the state's infrastructure is estimated at over $1.1 billion dollars in direct and indirect damages, as well as total job losses of over 15,000 (RESI 2008).

Other infrastructure at risk includes marinas along Chicago's lakeshore. As water levels drop, the nine lakefront marinas that are currently operating at near capacity levels (Westrec Marinas) may be in jeopardy. Chicago's marinas are operated by a private firm, making it difficult to estimate revenues. However, averaged over the entire industry, it is estimated that one marina makes $400,000 in annual revenues – making it a $3.6 million enterprise in Chicago (Hoover's 2008). Boating is a popular pastime in Illinois with over 380,000 boats registered in the state (NMMA 2005). If marinas are no longer accessible, the entire industry surrounding this activity may suffer.

Another vulnerability may be the public highway system's roads and other publicly funded transportation systems, such as railroads. For example, there are 2,442 structurally deficient bridges (US DOT 2004), which may become more stressed if waterborne shipping has to be diverted to the highways.

Agriculture
Crop production in Illinois employs nearly 10,000 people with nearly 3,000 more employed in agriculture and forestry support activities (BLS 2002). The market value of agricultural products sold was over $8.9 billion in the state. The market value of crops

sold topped $6.8 billion and milk products accounted for $265 million (USDA 2002). While it is difficult to predict how increases in carbon dioxide gas in the atmosphere will impact Illinois' agriculture, other impacts are clearer. For example, one study estimated the projected change in runoff and soil loss resultant from projected changes in precipitation in the state. It found that the agricultural areas in Illinois may experience a 7.7-18.6 percent increase in runoff and an 18.9-37.5 percent increase in soil erosion (O'Neal 2005). Both of these factors will likely impose higher costs on agricultural production. A study[2] examining potential profit damages from projected climate change impacts on Midwest agriculture found that given a 4.5°F increase in temperature and a 7 percent increase in precipitation, net profit of the agricultural sector decreases by $9.28 billion annually. A more accurate model estimation which includes long-term climate variation projects that the actual losses may be quadrupled – at $41.46 billion in annual losses (Dixon and Segerson 1999).

Another concern with agriculture is the potential drier weather resulting from higher temperatures. The percentage of irrigated farms in 2002 was 2.8 percent - an increase from 2.6 percent in 1997 (USDA 2002). If drought does become a concern, more and more farms will have to invest in expensive irrigation equipment to stay viable. Additionally, the increases in precipitation will likely come in the form of heavy rainfall events, potentially causing floods and inflicting economic damages to the farmers rather than providing relief from drier conditions.

The dairy industry is vulnerable to temperature increases. More specifically, dairy production decreases at temperatures around 90°F, and losses begin to be felt when temperature reaches 77°F. This productivity loss can translate into economic costs. For example, in California, higher temperatures were responsible for 7-22 percent decline in dairy production by the end of the century (PNAS 2007). Illinois is predicted to experience a rise in very hot days, which will likely impact this multi-million dollar industry.

Water Resources

As temperatures increase, water availability in Illinois may become an important concern. In addition to precipitation, Illinois receives surface water from rivers flowing through Indiana and Wisconsin, as well as Lake Michigan (Wistanley and Wendland 2007). Water levels in the aquifers affect pollution levels which in turn impacts the costs of water treatment. A survey conducted by the EPA in 2004 found that Illinois needed $15.2 billion in 2004 to meet water quality standards set forth in the Clean Water Act (EPA 2004). A study in Texas found that increased contamination of surface water raised the treatment costs by 27 percent (Dearmont 1997). Impacts induced from climate change such as more frequent flooding is likely to increase the treatment costs in Illinois, as well.

[2] The study used county-level data from four agricultural census and USDA's climate data – seasonal temperature and precipitation and data on soil and site characteristics, as well as extensive climate variables in the county, incorporating diurnal temperature variation and seasonal data. It further incorporated market year prices for major crops, value of the livestock, geographical categorizations (Dixon and Segerson 1999).

If additional pollutants in Illinois' water network increased by 10 percent, the state will need an additional $1.5 billion to meet federal requirements.

Human Health

There are many ways in which human health may be impacted – higher temperatures coupled with more frequent rainfall events and potential flooding with standing water are conducive to bacterial and insect reproduction. If there is no infrastructure to properly treat storm water, infectious diseases may spread into the water supply. Well thought-out storm water management systems and emergency response systems need to be in place to prevent worst impacts. Another potential public health threat is related to the projected temperature increases. Impacts of heat on susceptible populations may be very dangerous, sometimes resulting in stroke and death. The deadliest heat wave on record happened in 1995 with 753 deaths in Illinois, also causing major power outages (Illinois State Water Survey 2003). The effect has been observed to be greater in urban settings. For example, during July 1980, a heat wave resulted in an increase of 57 percent in heat related deaths in St. Louis and 65 percent in Kansas City, Missouri as compared to the year earlier. In the rural and suburban areas in the rest of Missouri, on the other hand, the mortality increased only by 10 percent (Noji 1997).

MISSING INFORMATION AND DATA GAPS

The impacts of continued climate change will likely be widespread in Illinois. However, the comprehensive economic effects remain ellusive. For example, it is unknown what the additional economic impact on road infrastructure and congestion will be, if the Great Lakes-St. Lawrence waterway becomes unavailable for commercial shipments and other modes of transportation will have to be used. Since temperature and climate variability have such a profound impact on species distribution and migration, it is difficult to estimate the economic damages to agriculture and the wildlife recreation industry from loss of habitat. Human health is likewise dependent on many environmental, social, and economic factors whose interactions determine the impact. Greater research into human health impacts due to climate change effects is warranted.

CONCLUSION

Climate change is expected to bring more frequent precipitation along with higher temperatures to Illinois. More intense precipitation will likely increase flooding events. Nonetheless, higher temperatures are expected to offset the added precipitation resulting in lower water levels in Lake Michigan. These climatic changes will likely undermine an important shipping route for the economically critical manufacturing sector. Infrastructure damages will likely amplify from more frequent flooding, which will likely impact the public highway system, as well. The agricultural sector is projected to face increased costs from greater soil erosion and runoff, as well as the growing need for expensive irrigation. Water supplies throughout the state may be exposed to more contaminants requiring greater water treatment costs. Human health impacts are also expected.

Lessons Learned

As we begin to quantify the potential impacts of climate change and the cost of inaction, the following five lessons are learned:

1. There are already considerable costs to society associated with infrastructures, agricultural and silvicultural practices, land use choices, transportation and consumptive behaviors that are not in synch with past and current climatic conditions. These costs are likely to increase as climate change accelerates over the century to come.

2. The effects of climate change should not be considered in isolation. Every state's economy is linked to the economies of surrounding states as well as to the national and global economy. While the economic costs of climate change are predicted to vary significantly from state to state, the negative impacts that regional, national and global markets may experience are likely to affect all states and many sectors.

3. While some of the benefits from climate change may accrue to individual farms or businesses, the cost of dealing with adverse climate impacts are typically borne by society as a whole. These costs to society will not be uniformly distributed but felt most among small businesses and farms, the elderly and socially marginalized groups.

4. The costs of inaction are persistent and lasting. Benefits from climate change may be brief and fleeting -- for example, climate does not stop changing once a farm benefited from temporarily improved growing conditions. In contrast, costs of inaction are likely to stay and to increase.

5. Climate models and impact assessments are becoming increasingly refined, generating information at higher spatial and temporal resolutions than previously possible. Yet, little consistency exists among studies to enable "summing up" impacts and cost figures across sectors and regions to arrive at a comprehensive, state-wide result.

6. To provide not just a comprehensive state-wide assessment of impacts and cost, but to develop optimal portfolios for investment and policy strategies will require support for integrative environmental research that combines cutting-edge engineering solutions with environmental, economic and social analysis. The effort and resources required for an integrative approach likely pales in comparison to the cost of inaction.

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