The Social Scientific Approach to Climate Change Science within the United States Federal Government

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A New York City transportation planner, a United States (U.S.) Great Plains farmer, and a Western U.S. water manager have more in common than one would imagine. They are all decision makers acutely aware of the effects of short- and long-term climate impacts in their decision-making, but most likely do not have a comprehensive understanding of the socioeconomic and decision support dimensions of climate research. If they do not use climate forecasts information, it may be because they do not receive climate forecasts in a format needed to make an informed decision, the data may not be available at the time they need it or they simply cannot understand the data or its potential use. For those decision makers that do make decisions based on climate forecasts, they have learned to plan given a variety of dynamic information.

Within the United States federal government, the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)'s Climate Program Office (CPO) has several programs that work with decision makers and scientists to better understand how to relay climate forecast information through enhanced communication, tool development and outreach activities to better serve those in decision making positions for planning when climate has an impact.

This paper will begin with a brief discussion of historic and present efforts in the field of human dimensions of climate within the US Federal government, focusing on the work administered through NOAA. We will then take a look at three decision makers that represent recent studies funded by our programs that demonstrate the importance of social science methodologies and stakeholder involvement. Finally, we will focus on lessons learned within NOAA's human dimensions-focused programs that will shape future research intended to help these decision makers better use climate forecast information.

US Federal Agency Efforts within the Human Dimensions Realm

Within the US Federal Government there are a number of agencies that work directly or indirectly with understanding and interpreting the impacts of climate variability and change. When I originally sent in the abstract for this conference, I proposed to give a brief synopsis of the overall federal social science effort within the climate change sciences and then speak about my own agency. However, once started, this task has become daunting because even within my own agency, it appears that we are in the midst of a transformation in paradigms where it now appears to be in vogue to say that one's program works with social scientists and communicates with stakeholders on a regular basis. Recent meetings have shown that an increasing number of the heads of these programs believe that they work with "decision makers" and therefore are in touch with the human dimensions aspects. After all, they claim, we are all humans and we are concerned with the climate.

In fact, at a recent web meeting in which we were preparing our NOAA websites to highlight climate-related activities in anticipation of the release of the IPCC Working Group II report, 75 different programs within our small agency replied to a data call that their information was relevant to the second volume of the IPPC on "Impacts, Adaptation, and Vulnerability." As a social scientist, I marveled at the metamorphosis that has occurred in our agency over the last few years from a science-producing agency to now, where it is important to show the relevance of the science and to be able to openly incorporate social science inputs into public products. However, while some programs have not yet or are just beginning to understand the value of social science within their own programs, there still has been a sea change in approach and this should be recognized.

Part of NOAA's change began in 2003 when there was a realization within our agency of the importance of including social science researchers and methodologies in a predominantly natural science agency. The Agency's Science Advisory Board convened a special committee to study the potential of using more social science within the Agency and how to incorporate those changes. The result was a report entitled "Social Science Research within NOAA " (NOAA Science Advisory Board 2003) in which the committee laid out specific steps that could be taken to better incorporate a range of topics from economics to psychology into NOAA. Change is slow in a bureaucracy, however, it does happen and the first official Social Science Committee was convened in March 2007.

While social science is a new and potentially important aspect of NOAA, it has been alive and functioning within NOAA's Climate Program Office for several decades. Originally, the program most associated with the social sciences was the Human Dimensions of Global Change Research Program. Over the years it has evolved, and today there are three closely related and functioning programs within the Climate Office that are interdisciplinary in nature, namely the Sectoral Applications Research Program (SARP), the Regional Integrated Sciences and Assessments Program (RISA), and the Transition of Research Applications to Climate Services (TRACS). To better understand the present human dimensions work, it is important to take a quick look at how social science, specifically the human dimensions work has evolved within NOAA.

The Evolution of the Programs

NOAA began investing in human dimensions in the early 1990s. The original US Human Dimensions of Global Change Research Program "gave birth" to several like-minded programs including RISA, Environment Science and Development (originally the Research Applications Program), and Climate Variability and Human Health. It appears that these programs have gone through four stages of development from the early 1990s until today including: Conducting Impact Assessments; Performing Field Experiments, Understanding the Potential Use of Climate Information, and Using Climate Information in Planning. A very brief discussion of each phase follows.

Conducting Impact Assessments. The early projects funded in the realm of human dimensions were what one would expect in the early stages of a new discipline. Federal managers and researchers alike were most interested in assessing the impact of climate. One project funded during this time was led by Allan Auclair (2007) who conducted a study entitled "An Integrated Assessment of the Social and Economic Effects of Extreme Climatic Fluctuations on Forests in the Northeastern United States". In this study, he examined the effects of changes in climate fluctuations that affect forest dieback and growth on the social and economic conditions and ultimately on the decisions for the locale and the region. Michael Glantz conducted a NOAA-funded study during this time "Assessing the Use and Value of ENSO Information for Food Security in Southern Africa." This study (Glantz 2007) focused on whether and how responses to the drought that occurred in South Africa during the 1991 El Nino may have been altered if information been available to the food security decision-makers during the spring, when experimental ENSO forecasts had been issued. While these forecasts were available, they were not widely circulated to potential users.

Performing Field Experiments. During the 1997-98 El Nino event, a series of field experiments were led by NOAA in partnership with international, national and local organizations, including the US National Science Foundation, Inter-American Institute for Global Change Research, United States Agency for International Development, World Meteorological Organization, International Research Institute, etc. in which they convened a series of Climate Outlook Forums in Africa, Asia, Latin America and Caribbean. The primary focus of these meetings was the development, assessment and distribution of experimental, consensus climate forecasts for use in resource management. A number of these forums continue today. For example, in early March 2007, the nineteenth Climate Outlook Forum was convened in Nairobi, Kenya to formulate consensus guidance for the March to May rainfall season in the Greater Horn of Africa. Also held during the 1997-98 El Nino was the ENSO Health Experiment in which various medical and climate researchers led 25 separate projects focused on the influence of climate on diseases such as cholera, dengue, malaria, and hanta virus. Jennifer Phillips performed a NOAA-funded project entitled "Surveillance and Monitoring of Health Consequences of the 1997-98 ENSO in Mozambique" during that time.

Understanding the Potential Use of Climate Information. After the 1997-98 El Nino, social scientists began to realize the potential benefits of using climate forecast information in planning. Kathleen Miller and Robert McKelvey (Miller 2000) studied "Climatic Variations and the International Management of the North American Pacific

Salmon Fishery: A Game Theoretic Perspective". They concentrated their study on the northwestern border of the United States with Canada where salmon spawned in one area are often harvested in another. Aggressive harvesting led to a breakdown of cooperation between fishermen across the border; it was made particularly difficult with climate changes that impacted sea temperature and the fish migration patterns. These researchers developed a mathematical game model to simulate migratory patterns, changes in fish stock, and the effects of scientific information. Among the factors they included in the model were: fish characteristics (spawning stock, size of offspring, location of fishing grounds, etc.); environmental factors (including climatic regime shifts); cooperative and competitive payoffs to players; and quality and accessibility of information. The results of this study were provided to policy makers and stakeholders in region; they were later used by the United Nations Food and Agricultural Organization at an international meeting on management of shared fish stocks and as state-of-the-art advice for talks on shared fishery regimes.

Using Climate Information in Planning. We are presently in a phase when planners are realizing the potential benefits of the use of climate information in planning for the future. One study, headed by Roberta Balstad of Columbia/CIESIN was a pilot project to better understand the needs of urban planners in planning for climate change. This project is highlighted later in this paper (Balstad 2007).

Another project, presently being undertaken is by Joel Smith of Stratus Consulting who began to work with the City of Boulder, Colorado's planners to examine the city's vulnerability to long-term climate change and climate variability (Smith 2007) . Usually, water managers plan for floods and droughts by looking at past history. In the observed record, this often means that a planner will have about 50 years of data or less to use to predict future climate impacts. The problem is that the recent past may not adequately represent what the future will hold. For example, there are most likely climate-related episodes that would not be included in the observed record such as the drought during the Dust Bowl years or the floods in the south attributed to hurricanes such as the Great Galveston Hurricane of 1900. Through extensive analysis of the paleoclimate record, in which they have developed reconstructions of the last 400 years of stream flows from tree rings and other sources, the researchers will use the reconstructions in combination with climate change models for the city in order to evaluate the risks from both climate change and climate variability. In other words, water managers in this city, will be able to examine what would happen if past droughts happen again, but this time under warmer conditions consistent with climate change. This new methodology will provide an improved tool for water resources planning.

Communication is key to the use of climate information planning. In 2005, Tony Patt (Patt and Gwata 2007) completed a study, "Testing the Ability of Subsistence Farmers to use Seasonal Climate Forecasts: A Participatory Approach in Zimbabwe." He found that despite the possibilities of improving their quality of life, many potential users of climate forecasts do not use the information as much as planners and scientists had hoped. This was particularly true in Zimbabwe where the climate signal could have improved the economic status of local farmers. Patt et al. worked with farmers in this area using participatory communication practices to overcome farmers' difficulty understanding and applying the climate information. The farmers that used this approach planted different crop varieties and changed other management decisions resulting in benefits from the seasonal forecast (Patt 2005).

Social Science and Climate Change Research within NOAA's CPO[1]

The aforementioned programs, RISA, SARP, and TRACS along with the International Research Institute for Climate and Society (IRI) together form the Climate Assessments and Services Division (CASD) which help NOAA identify and serve the nation's needs for climate information to support decision making through an integrated program of: 1) research and assessment related to impacts and decision making needs; 2) transition of research to operations; and 3) experimental production and delivery of local and regional climate services that can be utilized to enhance adaptive management options. NOAA's CASD activities include efforts managed by the research and operational entities of the agency, and involve productive partnerships with other agencies, universities and stakeholders. These programs rely on the use of a combination of social and natural science approaches to produce tools, models and methodologies for decision makers that enhance their current ability to deal with changing climate patterns and that are expected to help them in future planning.

Three Decision Makers and what We have Learned to Make Their Jobs Easier

Let us take a look at our three aforementioned decision makers to better understand how social science methodologies have helped decision makers in incorporating climate forecast information into their decision making process.

The New York City transportation planner. The tri-state New York City (NYC) metropolitan area, with 20 million people living, working and commuting in its 31 counties, is home to the largest public transportation system in the United States. Four out of five of New York's boroughs are located on islands. The bridges and tunnels that connect these boroughs are critical conduits along the main transportation paths to the suburbs and counties located in the region and are critical for national and global commerce. The potential impacts and costs associated with climate variability and change along with the rebuilding of aging infrastructure that is already taking place in this region could potentially stress the regional economy and impact the lives of millions of residents.

[1] A quick hierarchy of this program is as follows. The Secretary of the Department of Commerce is within the President's cabinet. The National Oceanic and Atmospheric Administration (NOAA) is one agency within this department. Its climate mission is to "Understand and describe climate variability and change to enhance society's ability to plan and respond." Within NOAA, is the Climate Program Office (CPO). This office is the focal point for climate activities within NOAA and its objectives include: (1) Describe and understand the state of the climate system: (2) Reduce uncertainty in the information on atmospheric composition and feedbacks; (3) Provide climate forecasts for multiple time-scales to better plan for the impacts of climate; (4) Understand and predict the consequences of climate variability and change on marine ecosystems; and (5) Provide information and tools to support decision makers.

Our planner is faced with a number of decisions. Climate forecasts should be integral to this planner. For example, the city's sewer system was designed over 150 years ago; some of the pipes still in use were laid when the system began. By 2030, nearly every other major infrastructure within New York City will be over 100 years old and in need of maintenance and/or upgrading. As a result, the city is now faced with billions of dollars of future expenditures to replace these aging structures. Given that the rate of relative sea-level rise in New York City is 0.11 inches/year (2.73 millimeters/year) and that sea level in the New York metropolitan region is rising more quickly than global sea level (probably due to ongoing regional subsidence), the design of these new pieces of infrastructure should take into account continued rise in sea level.

Our planner should also take into account extreme events. At the end of August 1999 after a number of months of drought, the New York region was subjected to a heavy rainstorm. Between 2.5 and 6.1 inches (6.4 and 15.5 cm) fell in flash floods that crippled the region's mass transport system. The following morning, up to 5 feet (1.5 meters) of water covered the power tracks in various parts of the New York City subways, stopping service and stranding passengers on numerous lines. Besides the subway, bridge access roads, entrances to road and rail tunnels, and many transportation facilities were put in jeopardy by flooding, including all three of the major New York metropolitan region airports, two tunnels vital to commuter traffic, the Passenger Ship Terminal, and major road arteries. Projections have been made about the height of future floodwaters, particularly if they occur in conjunction with a rise in the level of the rivers bisecting New York City. These projections indicate that at the least some transportation facilities could be under 6 to 16 feet of water. This is particularly worrisome to our transportation planner as many elements of the transportation and other essential infrastructure systems in the New York metropolitan region are located at elevations two to six feet above current sea level.

Surprisingly, until recently, climate was not a major a consideration in New York City transportation planning. In 2002, our Human Dimensions program funded a projected headed by Dr. Roberta Balstad at Columbia University/CIESIN (Balstad 2007). The project team convened an advisory committee composed of decision-makers from the region involved in policy-making at a variety of levels. Through a series of meetings, the project team identified key sources of information needed by these decision makers and developed a website for their use.

In creating the new website, the team first assessed the information needs of urban policy makers, analyzing both the ways that they obtain and use information and the kinds of information that they take into account in their work. The team gathered and organized existing climate forecast, policy, and scientific information and also tried to anticipate how urban climate change information would be maintained and used in the future. Potential users of CCIR-NY include: city, municipal, and county planners; natural resource managers; transportation managers; water managers; waste managers; educators and citizens.

The recently released website can be found at http://ccir.ciesin.columbia.edu/nyc. It is an easy-to-use information resource that is expected to foster better decisions related to the health, safety and livelihoods of the citizens in the region. The site is designed to be useful to all levels of readers, from climate experts to grade school students. In addition to providing basic information about climate in the New York City metropolitan area, the website provides users an opportunity to become part of a network that will share expertise and information related to climate change and variability in the New York City Metropolitan Area, join an email list where interested individuals may discuss items related to climate change and variability impacts on urban environments, and browse a resource list that includes web links and a bibliography of publications related to the topics discussed on the website.

There has been worldwide interest in this study. The researchers are presently working with planners in Tokyo and London on developing similar information tools in their locations.

The Great Plains U.S. Farmer.

Nebraska is a state located in the U.S. Great Plains. The state experiences large seasonal variations in both temperature and precipitation. Precipitation also varies geographically, with an average annual precipitation of 31.5 inches (800mm) in the southeastern corner of the state to about 13.8 inches (350 mm) in the central part of the state. Agriculture is important to the economy of Nebraska; the state is a national leader in the production of beef, pork, corn (maize), and soybeans. Drought, which has impacted this area over the last six years, is of major concern to the residents of this area, as this was the site of the Dust Bowl of the 1930s.

Our farmer lives in Nebraska and is aware of the physical dimensions of climate research, but most likely those supplying climate information do not understand how the information is ultimately used in decisions made on his farm.

Through a series of NOAA-funded studies in this area, investigators have found that despite increasing accuracy in weather and climate forecasts, Nebraskan farmers use of forecasts and climate information in making farming-related decisions have not followed because of (1) the farmers perception of the utility and value of the forecasts for farming decisions; (2) the perception of “expert viewpoints” by social groups to which they belong; and (3) the perceived identity and reliability of the forecast makers (Hu 2006). It appears that attitude, social norm, perceived behavioral control and financial capabilities motivate farmers the most to use weather and climate information and forecasts and for making decisions (Artikov 2006).

While many Nebraskan farmers incorporate sustainable management practices as normal operating procedures others have begun to adopt them in anticipation of further drought. (Knutson) Farmers have taken a variety of steps in this area because of the prevalence and frequency of drought. For example, among the most cited practices used by livestock producers to reduce the effects of drought were (1) reducing the number of cattle on their land by selling them earlier, (2) selling off more or buying few calves and yearlings and (3) keeping fewer replacements.

This study has shown that for our Nebraska farmer, improvement in the forecast would certainly increase his use of climate forecast information in decision-making. When asked how drought and climate products could be enhanced to meet their needs, some of the ideas given by farmers in this study included providing climate forecasts via a more accessible media such as on the radio at a certain time every morning; development of new products such as detailed humidity forecasts, current conditions and forecasts of the water table, etc.; and creating a network of producers that would report on current conditions and impacts such as storms, etc. These studies have shown that our Nebraska farmer could be further helped with enhanced communication networks, and paying particular attention to the social and economic aspects of decision making when promoting the use of climate forecast information.

Recognizing this need for better communication of drought information to water users in the Midwest and western portions of the country, the governors of this area commissioned a report that was written by scientists and natural resources managers from across the country, representing various federal and state agencies and non-governmental organizations. In 2004, they unanimously adopted this report that recommended that water users should have the ability to assess their drought risk in real time and before the onset of drought, in order to make informed decisions that may mitigate a drought's impacts (Western Governor's Association 2004). In December, Congress passed the National Integrated Drought Information System (NIDIS) bill, which will establish a drought early warning system that will coordinate and integrate a variety of observations, analysis techniques and forecasting methods in a system that will support drought assessment and decision-making at the lowest geopolitical level possible. In recognition of the human dimensions aspect, our office has received money and will be funding research projects on coping with drought.

<u>The Western US Water Manager</u>

Picture the overworked western US water manager. She lives in one of the most glamorous regions in the United States with enviable weather and vistas. Instead of enjoying her environment, she must spend her time keeping up with a myriad of new information. Besides understanding hydrology, she must be educated in a number of other fields. For example, she must keep abreast of changing demographics including increases in population, changes in age pyramids, etc. On top of this, she needs an education in law to understand the complicated domestic and international water laws for extracting water. She must balance demands from urban areas with those of some of the richest agricultural districts in the US. She must be familiar with flood impacts (including mud slides, road closings, and the potential impact on livestock) as well as drought (including imposing restrictions on water use, impacts on agriculture, and widespread wild fires that are becoming more prevalent each year). Finally, she must understand the impacts of climate, particularly in El Nino and La Nina years. In brief, the physical aspects of her job are as important as knowing about the socioeconomic ones.

Through several projects, we have learned a great deal about water managers and their use of climate forecast information. For example, water managers within the United States can be a one-person operation for a small community in Pennsylvania to one that services millions of people in an urban area. According to a study by Yarnal et al. (O'Connor R.E. 2005), most water managers that they surveyed in rural Pennsylvania and South Carolina make minimal use of climate forecasts. They found that assessments of the reliability of weather and climate forecasts were not driving their use; instead, the strongest determinant of forecast use is risk perception. They found in their study areas that water managers who expect to face problems from weather events in the next decade are much more likely to use forecasts than are water managers who expect few problems. Much of their perception of the future was based on their past experiences. As a result, they found that water managers, who had problems with specific types of weather events such as flooding within the last five years, were more likely to expect to experience problems in the next decade. In conclusion, feeling at risk rather than a long-range forecast, stimulates a decision to use weather and climate forecasts.

Rayner et al. (2005), conducted case studies in California, the Pacific Northwest, and metropolitan Washington DC, and also found that water resource managers in the United States are reluctant to incorporate climate forecast information in decision making. In their study, managers cited problems with forecast reliability as their reason for not using forecast information; however, the researchers refuted this claim as they found through interaction with those managers, that the managers did not know enough about forecast performance or the level of reliability that they would need for their decision-making. Instead, the researchers ascertained that institutional reasons (e.g., traditional reliance on large built infrastructure, organizational conservatism and complexity, mismatch of temporal and spatial scales of forecasts to management needs, political disincentives to innovation, and regulatory constraints) appear to influence water managers' reluctance to use the forecasts. The authors propose that water managers will begin to use forecasts as they are incorporated in existing organizational routines and industrial codes and practices, as changes in management provides incentives for innovation, and as finer spatial resolution of forecasts becomes available.

Through a series of interviews with water resource decision makers and Federal officials, Kathy Jacobs (2002) developed a list of suggestions for increased integration of science and decision-making. Among her suggestions were to understand the context in which decision are made and encourage institutional change, focusing on interdisciplinary research and applied knowledge. She maintains that scientist and water managers approach climate from different perspectives and that these need to be better understood or interpreted to encourage enhanced use of climate information in decision making.

Finally, there have been a number of projects that have been undertaken to incorporate climate forecast information into decision-making. For example, since 2002, the California Energy Commission, CALFED, and NOAA-CPO have been supporting the Integrated Forecast and Management (INFORM) Project. INFORM is a research and demonstration project for assessing the use of integrated climate forecasting in managing the Folsom, Shasta, Oroville, and Trinity reservoirs. Its objective is to demonstrate possibilities for increased water-use efficiency in Northern California water resource operations through innovative application of climate, hydrologic and decision science, and reciprocal technology transfer activities. Among the lessons learned from this project are (California Applications Project 2007): (1) communication enhances credibility; (2) relationships with end-users need to be cultivated; (3) collaborations with large institutional programs are key; (4) climate data needs to be updated and maintained; (5) simple, clear illustrations are needed; and (6) the interest level of public and private sectors varies.

Based on these studies, we foresee an easier life for our western US water manager in the future as better tools and methodologies are adopted.

The Future

Much progress has been made since the 1990s in terms of social science research. The U.S. Federal Government has increasingly realized its importance. In the future we will begin to see and expect that social science methodologies coupled with the inclusion of decision makers will be included in discussions of new climate products and tools.

Within NOAA, social science research (particularly through the Human Dimensions program) has taught us that (1) interdisciplinary research is important and that the use of social science tools and methodologies is key in incorporating decision makers needs and use of the science; (2) communication is critical to the better use and understanding of forecasts. This includes scientists to decision makers as well as the reverse, decision makers to scientists; (3) there is a distinct need for climate interpreters to improve communication. For example, many of these users know about climate models, but do not understand the subtle differences between atmospheric variables used. On the other hand, scientists know how to talk about their work, but most likely have not had training or experience communicating scientific information to non-scientists. We need to employ people who understand how to communicate scientific ideas to users; (4) methodologies need to be new and innovative; however, they should be derived from that which we know already works. For example, a case study approach can be combined in a GIS with scientific and socioeconomic information to provide a decision support tool; (5) this field is new and developing, we need to convince others of its importance.

As scientists, social and physical working together, our roles will become increasingly important to our vulnerability to changes in the climate and our ability to prepare for the future.

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