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PERCEPTION AND EXPECTATION OF CLIMATE CHANGE

Precondition for Economic and Technological Adaptation

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CLIMATE CHANGE, STRATOSPHERIC ozone depletion, and the loss of biodiversity are the three most significant environmental changes currently occurring on a global scale (National Research Council, 1992, pp. 18–21). Macroeconomic impact models of environmental change crucially depend on a realistic set of assumptions about human adaptation to such change. These assumptions should incorporate knowledge about human capabilities and limitations in attention, perception, memory, and information processing. A comprehensive summary of the current state of knowledge and future research directions on these issues was provided by the Committee on the Human Dimensions of Global Change, commissioned by the National Research Council. Its report divides human

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response to global changes into a hierarchical set of seven interacting systems, with the most fundamental system being "individual perception, judgment, and action" (National Research Council, 1992, p. 5). The study reported in this chapter is intended to contribute to our understanding of the human response to one important class of environmental change, namely climate change and the possibility of global warming. As agriculture is one area of the economy that will be affected by climate change in a direct and major fashion, the perceptions, judgments, and actions of farmers are a crucial component in the determination of the immediate and ultimate consequences of climate change and are the topic of this chapter.

Growing concern about greenhouse gases and their effect on the global climate over the last decade has resulted in analyses of the impact of climate change in a variety of areas, including agricultural production and food security. In a review of such studies, Sonka (1991) noted several methodological weaknesses. One weakness is the assumption of an instantaneous change in climate rather than a gradual warming trend over a number of decades. Another is that climate is the only factor assumed to change from current conditions, despite the likelihood that a changed climate some twenty to fifty years into the future will face a world greatly different from today's. Global population growth and technological change are only two factors that, in addition to climate change, will significantly affect food security.

Global change in agricultural production will come about as the sum of gradual adjustments made by individual farmers as they perceive gradual local changes in weather and climate. Yet few agricultural impact assessments consider adaptation to a changing climate as a dynamic process. One exception is the work of Kaiser and others (1991), which simulates individual farm decisions over a series of years. Agricultural production is affected by climate change through changes in annual production decisions. The simulation assumes, however, that decisions are made with perfect accuracy in expectations of the altered climate. Absence of a better alternative (such as a more realistic set of assumptions about the nature and quality of decision makers' climate expectations) is a likely explanation for this clearly unrealistic assumption (Bullard, 1990).

In summary, one may question the answers provided by previous agricultural impact assessments because these models have tended to (1) assume an instantaneous change in climate, (2) focus exclusively on physical and biological processes, (3) assume perfect accuracy in expectations about climate changes, and (4) ignore the adaptations that individuals and society can and will implement over time as climate changes (Ausubel, 1983; Bartlett, 1980;

Glantz, Robinson, and Krentz, 1985). The goal of this chapter is to provide information that will help modelers to make more realistic assumptions on all four issues, but in particular on issues 3 and 4.

Detection of Climate Change

Changes and trends in local weather and climate patterns are not easily detected. A lot of scientific uncertainty surrounds the nature and magnitude of climate change (Begley, 1993; National Research Council, 1979, 1982, 1992; Smith, 1995; Trefil, 1990). The Intergovernmental Panel on Climate Change (IPCC), established by the World Meteorological Organization and the United Nations Environmental Program in 1988, reported in 1990 that the size of global increases in surface air temperature was "broadly consistent with predictions of climate [change], but also of the same magnitude as natural climate variability," with an "unequivocal detection of the enhanced greenhouse effect from observations not likely for a decade or more" (Houghton, Jenkins, and Ephraums, 1990, p. 2). General circulation models, the complex computer simulation models used to predict the effect of greenhouse gases on local and global climate, are highly sensitive not only to assumptions about future levels of greenhouse gases but also to design features such as the density of the grid imposed on the earth's surface (Dickinson, 1986; Trefil, 1990). Thus IPCC's 1990 estimate of climate change by the year 2030 for central North America forecasts warming between two and four degrees in winter and two to three degrees in summer, and precipitation increases from 0 percent to 15 percent in winter and decreases of 5 percent to 10 percent in summer. Its best-case scenario, however, reduces these numbers by 30 percent, and the worst-case scenario increases them by 50 percent.

Given the scientific uncertainty surrounding climate change and the gradual nature of any change, in conjunction with the importance of detecting such change at the local level in order to develop adaptive responses, it is imperative to obtain answers to the following questions: Can individuals detect gradual changes in local temperature and precipitation against a background of large variability? What factors will facilitate or delay the perception or detection of such changes?

Role of Expectations

Presumably, the expectation of climate change plays a large role in both the detection of and adaptation to climate change. The literature on covariation assessment documents the impact of prior theories and expectations. Chapman and Chapman (1967) showed that the expectation of a relationship between two variables prompted by semantic associations is sufficient for people to perceive and report covariation even in sets of data where no covariation exists. Nisbett and Ross (1980) summarized a long string of studies showing that people will under- or overestimate actual statistical relationships depending on their prior expectations, a phenomenon that is mediated by people's tendency to focus on observations that conform to their beliefs (Mynatt, Doherty, and Tweney, 1977; Wason, 1960). While the strength of the objective evidence of covariation clearly plays some role in its detection (Wright and Murphy, 1984), the evidence is overwhelming that covariation detection is dominated by prior expectations. Alloy and Tabachnik (1984) showed that, as a mechanism in addition to confirmatory information search, people with and without expectations also differ in the amount of information they seek out. In particular, they seek out less situational information if they hold strong preconceptions about a given relationship. Finally, Bower and Masling (1978) showed that people's ability to encode and subsequently retrieve correlated information is greatly enhanced when those correlations can be explained on the basis of prior expectations.

An interesting historical example of how climate expectations can affect the detection and acknowledgment of objective weather patterns is provided by Kupperman (1982). English settlers who arrived in North America in the early colonial period operated under the assumption that climate is a function of latitude. Newfoundland, which is south of London, was thus expected to have a moderate climate, and Virginia was expected to have the climate of southern Spain. Despite high death rates due to weather that was consistently much colder than expected, the resulting failure of settlements, and pressure from investors disappointed by the colonies' inability to produce the rich commodities associated with hot climates, colonists clung persistently to their expectations about local climate based on latitude. Reluctant to accept the different climatic conditions as a new fact in need of explanation, they instead generated ever more complex rationalizations and alternative explanations for these persistent deviations from their expectations. Samuel de Champlain, for example, took a single mild winter in 1610 as an indication that his mild climate expectations were justified after all, and suggested that the severe winters he had experienced during each of the six preceding years must have been what would nowadays be called statistical outliers.

Role of Experience

Given the large random fluctuations of climate variables over time, more experience with the natural variability in the level of these variables can be predicted to make it more difficult to believe that local patterns are evidence of long-term trends (von Furstenberg, 1990). Extended practice of an occupation (for example, farming) that focuses attention on weather and climate year after year may therefore make it more difficult to detect small climate trends embedded in random variability. A young farmer may, for example, see a succession of five or six hotter or drier years as evidence of a warming trend, whereas an older farmer may recall that similar runs occurred in the 1950s and 1960s but did not result in any permanent changes.

The importance of climate factors and climate change in agriculture and the importance of agriculture for the national economy and food security make farmers' expectations, perceptions, and adaptive responses to climate change an important topic of study. For this reason, the present study investigates the relationship between these variables in a convenience sample of Illinois cash-crop farmers.

Field Study

The present study addresses several questions.

Experimental Questions and Predictions

What proportion of farmers believe in climate change, and what is the nature and magnitude of temperature and precipitation changes they expect to see over the next twenty to thirty years? What causes farmers to believe in climate change? Does the expectation of climate change affect farmers' interpretations of current weather patterns? Do expectations or perceptions or both affect their adaptive responses? In what ways are farmers already responding to present or anticipated climate change? What are the consequences of their expectations for the success of their farm operations?

Participants and Instruments

Forty-eight farms were selected from a pool of participants in the Illinois Farm Business Farm Management (FBFM) association, a voluntary record-keeping cooperative. To keep the sample homogeneous on external variables, participation was restricted to farms that produced cash crops, were family operations, and had one primary and full-time owner and decision maker.

Use of FBFM participants provided access to detailed farm-level annual financial and production records for the seven years between 1985 and

1992. Survey responses could thus be linked to actual farm performance. Average farm size was 740 acres and ranged from 263 to 1,608 acres; approximately half of most farms' acreage was devoted to corn, the other half to soya bean production. Respondents were all male, had an average of 26.5 years of experience as the primary farm decision maker (with a range from four to sixty years), and fewer than half had attended college.

Individual structured interviews were conducted shortly before spring planting in 1993. They lasted between two and two and a half hours and involved 154 numerical, multiple-choice, and open-ended answers. Farmers provided information about their production and pricing decisions and other farm practices, and in particular about the following set of annual decisions: (1) what varieties of corn to plant, (2) when to start planting, (3) what tillage practice to use, (4) whether to buy, replace, or rent new equipment, (5) whether to purchase crop insurance and how much, and (6) how to price the crop. For each of these decisions, farmers reported what and how much information (past and present) they considered, from what sources they received this information, by what decision rule or process they arrived at their decisions, and what factors contributed to perceived decision difficulty. Details about this portion of the study can be found in Weber and Sonka (1994). Their main results, namely the identification of a set of management traits and the relationship of these traits to farm success, are summarized in the next section, as reference will be made to the management trait and farm success variables later on. I will then return to the topic of this chapter, namely farmers' beliefs and expectations about climate change and their current and anticipated responses to perceived or expected change.

Summary of Results of Weber and Sonka (1994)

Farmers' answers to questions asked about the seven annual decisions, their responses to other questions about production and pricing practices (the number of varieties of corn planted each year, acres allocated to experimentation, ownership and use of a personal computer), the keeping of climate records, the purchase of crop or hail insurance or both, the use of forward contracts or the futures market or both, the use of a regular before- or after-harvest pricing strategy either of their own design or provided by an expert, and their age, years of experience as primary farm decision maker, and education level were used as input variables into a principal components factor analysis that identified an underlying structure of seven management traits. Descriptive labels for these traits and the

Table 13.1. Management Traits and Contributing Variables with Factor Loading.

Trait	*Factor Loading*	*Contributing Variables*
Pricing sophistication	+.94	Prices production before harvest
	+.94	Uses forward contracts
	+.72	Uses pricing strategy of own design
Practical experience	−.60	Does not experience goal conflict
	+.79	Is older
	+.82	Primary farm decision maker longer
	−.60	Has less education
Active experimentation	+.57	Plants more varieties of corn
	+.53	Uses more acreage to experiment
	+.84	Owns personal computer (PC)
	+.87	Uses PC for farm business
Belief in collective wisdom	+.90	Other farmers provide information
	+.81	Does what other farmers do
Micromanaging	+.54	Uses short-term weather forecasts
	+.77	Time pressure makes decisions difficult
	+.60	Keeps weather and climate records
	−.57	No regular after-harvest pricing strategy
Systematic analysis	+.81	Uses market and price information
	+.50	Gets information from cooperative extension service
	+.57	Decides by objectively weighing options
	+.50	Conflicting information makes decisions difficult
Macromanaging	+.88	Farm magazines as source of information
	−.53	Professional consultant information not used
	−.51	No weather and climate records kept

list of contributing variables that had factor loadings greater than the absolute value of .50 for each trait are shown in Table 13.1.

Table 13.2 shows the distribution of the seven management traits in the sample of farmers. Trait strength for each farmer was classified as strongly negative ($t_i \leq -1$), moderately negative ($-1 < t_i \leq 0$), moderately positive ($0 < t_i < 1$), or strongly positive ($t_i \geq 1$), based on its estimated factor score. Table 13.2 shows that the distribution of some traits is skewed. Although the majority of farmers (74 percent) had positive scores on pricing sophistication, for example, the majority also had negative scores on active experimentation (63 percent).

Weber and Sonka (1994) argued that farm success can be described and quantified in different ways; they used five different proxies for it. The first one, net farm income standardized by the number of crop acres, is a measure of a farm's operational efficiency. The second and third, average prices received for either corn or soya beans received in a given year (in dollars per bushel), are measures of a farmer's pricing success. The last two, average crop yields for either corn or soya beans achieved in a given year (in bushels per acre), are measures of a farmer's production success. These measures were available for the seven years between 1985 and 1992.

To examine the relationship between the seven management traits on farm success, Weber and Sonka (1994) conducted a repeated measures analysis that included the five success measures for each of the seven years as dependent variables, the management traits as independent variables, and a variety of other variables that can be expected to affect the different

Table 13.2. Distribution of Management Traits Among Farmers.

	TRAIT DIRECTION AND STRENGTH			
Trait	*Strongly Negative*	*Moderately Negative*	*Moderately Positive*	*Strongly Positive*
Pricing sophistication	17	9	72	2
Practical experience	21	21	44	14
Active experimentation	12	51	21	16
Belief in collective wisdom	12	45	27	17
Micromanaging	13	45	25	17
Systematic analysis	16	37	21	26
Macromanaging	10	45	40	5

measures of farm success as covariates. These covariates were total crop acreage, total capital investment, total months of labor, soil quality, and the percentage of acreage in either corn, soya beans, or a government program. The most interesting result is that different management traits were associated with different dimensions of farm success. Micromanaging had a negative effect on prices but a positive effect on yields. Pricing sophistication had a positive effect on operational efficiency but no effect on prices or yields. Finally, active experimentation and systematic analysis had a positive effect on prices, in particular during the severe drought year of 1988.

Expectations of Climate Change

A large section of the survey evolved around farmers' attitudes and opinions about climate change. As shown in Table 13.3, responses to an open-ended request to describe the climate they were expecting in east-central Illinois in twenty to thirty years (which were subsequently content-coded) indicate that 53 percent of farmers did not expect any significant change in the climate; the other 47 percent expect the climate to be either warmer and drier (42 percent) or more variable (5 percent).

Farmers also rated their beliefs in the greenhouse effect, ozone depletion, and global warming on a scale from 1 (no belief) to 10 (very strong belief), with the opportunity to express no opinion. Only two farmers took advantage of the no-opinion option, and only for the greenhouse effect question. Mean belief ratings were 3.4 for the greenhouse effect, 4.8 for ozone depletion, and 3.7 for global warming, each with a range from 1 to 9. Belief in global warming had a correlation of .46 with belief in ozone depletion and of .78 with belief in the greenhouse effect. As the terms *global warming* and *greenhouse effect* refer to the same phenomenon (that the addition of carbon dioxide and other greenhouse gases to

Table 13.3. Expectations About Climate over the Next Twenty to Thirty Years.

Opinion	% of Respondents Holding Opinion
No or very little change	53
Warmer	19
Drier	2
Warmer and drier	21
More variable	5

the earth's atmosphere will cause the temperature of the earth to rise), the correlation of .78 between belief in global warming and belief in the greenhouse effect was appropriate and warranted. The depletion of the ozone layer that protects the earth from harmful ultraviolet rays, however, is a different phenomenon with a different set of causes (mostly the release of chlorofluorocarbon [CFC] gases used in air conditioners and industrial applications). Though CFCs alone cause warming, their ozone destruction can cause cooling, and these two effects tend to balance each other. That there was a significant and sizable correlation of .46 between farmers' belief in ozone depletion and in global warming can either be seen as an indication of a general disposition to believe or not believe in global environmental change or as an additional indication that the general population as well as media accounts in the United States tend to conflate these two issues (Bostrom, Morgan, Fischhoff, and Read, 1994; Read and others, 1994).

When belief ratings in global warming from 1 to 3 were coded as disbelief, 49 percent of the farmers fell into this category, broadly consistent with responses on the open-ended question about expectation of local climate in twenty to thirty years, where 53 percent indicated that they were not expecting any significant change from today. These two measures of belief were highly correlated with each other ($r = .92$, across respondents). None of the demographic variables (age, level of education) or length of farming experience were reliable predictors of whether farmers did or did not believe in global warming.

Two follow-ups to the open-ended question about local long-term climate expectations asked farmers for the change in average temperature and average annual rainfall they expect to see over the next twenty to thirty years. They were told to respond with zero if they expected no change, a negative number if they expected a decrease, and a positive number if they expected an increase. The two numerical change estimates were significantly different for those who indicated little or no belief in climate change (ratings of 1–3 on the belief scale) and those who indicated moderate or strong belief in climate change (ratings > 3): mean expected changes in temperature for the two groups were 0.8 and 2.5 degrees, and mean expected changes in rainfall were 1.0 and 3.7 inches, respectively ($F(1, 40) = 4.17$ and 4.23, $p < .05$).

Table 13.4 provides farmers' responses to a series of questions about the nature of the changes in temperature and precipitation that they would need to see in order to believe in the reality of global warming. Overall, farmers were looking for year-round temperature increases between two and five degrees and changes in rainfall between two and five inches over a period of at least ten years, with more variability in the direction of changes in precipitation than in temperature. It is encouraging to note that these changes given as requirements for a belief in global warming are well within the range of temperature and precipitation changes predicted by the IPCC that were described in the introduction.

Sources of Climate Change Expectations

Farmers were asked for the sources of their beliefs in global warming and climate change. They were given a list of five sources and asked to indicate which had influenced their opinion and to rank order those that had done so. The five source categories were popular media, agricultural newspapers, own experience, other farmers, and a catchall category, "other." Most farmers checked off either one or two of these categories as having had an influence on their opinion, with responses relatively evenly distributed across the first four categories. When the frequency with which different sources were acknowledged was cross-classified by whether farmers did or did not believe in global warming, there was a significant association between the two variables (chi-squared $(4) = 9.10$, $p < .05$). Farmers who believed in global warming were less likely to include popular media and more likely to include agricultural newspapers among their sources. They also listed more sources of influence than those who did not believe in global warming ($t(46) = 2.31$, $p < .05$).

Accuracy of Weather Memories

Prior to being asked about their beliefs regarding climate change, farmers were asked a series of questions about their memories of weather events in recent years. In particular, they were asked to indicate on a sheet of graph paper what they remembered about the total rainfall during the months of April and July over the previous seven years. The amount of rainfall during April and July is a crucial determinant of the quality and quantity of corn and soya bean crops and thus a salient variable in farmers' minds. The true values of total rainfall for east-central Illinois and their means between 1985 and 1991 are shown as solid lines in Figures 13.1 and 13.2 for April and July, respectively. Mean remembered values are indicated by the dashed lines, showing that, overall, farmers systematically misremembered April rainfalls as greater than they actually were and July rainfalls as smaller than the true amounts. It should be noted that this is the pattern of changes predicted by climate change models (see IPCC predictions in the introduction).

Table 13.4. Temperature and Precipitation Changes Required for Farmers to Believe in Global Warming.

Pattern of Change	*% of Responses*
Required temperature change pattern	
Warmer in summer	5
Warmer in winter	7
Warmer year-round	88
Over what number of years	
Five or less	27
Five to ten	36
Ten or more	36
Change in number of degrees	
Less than two	18
Two to five	70
More than five	12
Season of required rainfall changes	
In summer	5
In spring	2
All year	93
Required pattern of rainfall changes	
More variable	14
More	17
Less	43
Unsure or no opinion	26
Over what number of years	
Less than three	0
Three to five	27
Five to ten	60
More than ten	13
Change in number of inches	
Less than two	20
Two to five	60
More than five	20

Figure 13.1. True and Remembered Rainfall in East-Central Illinois During April, 1985 to 1991.

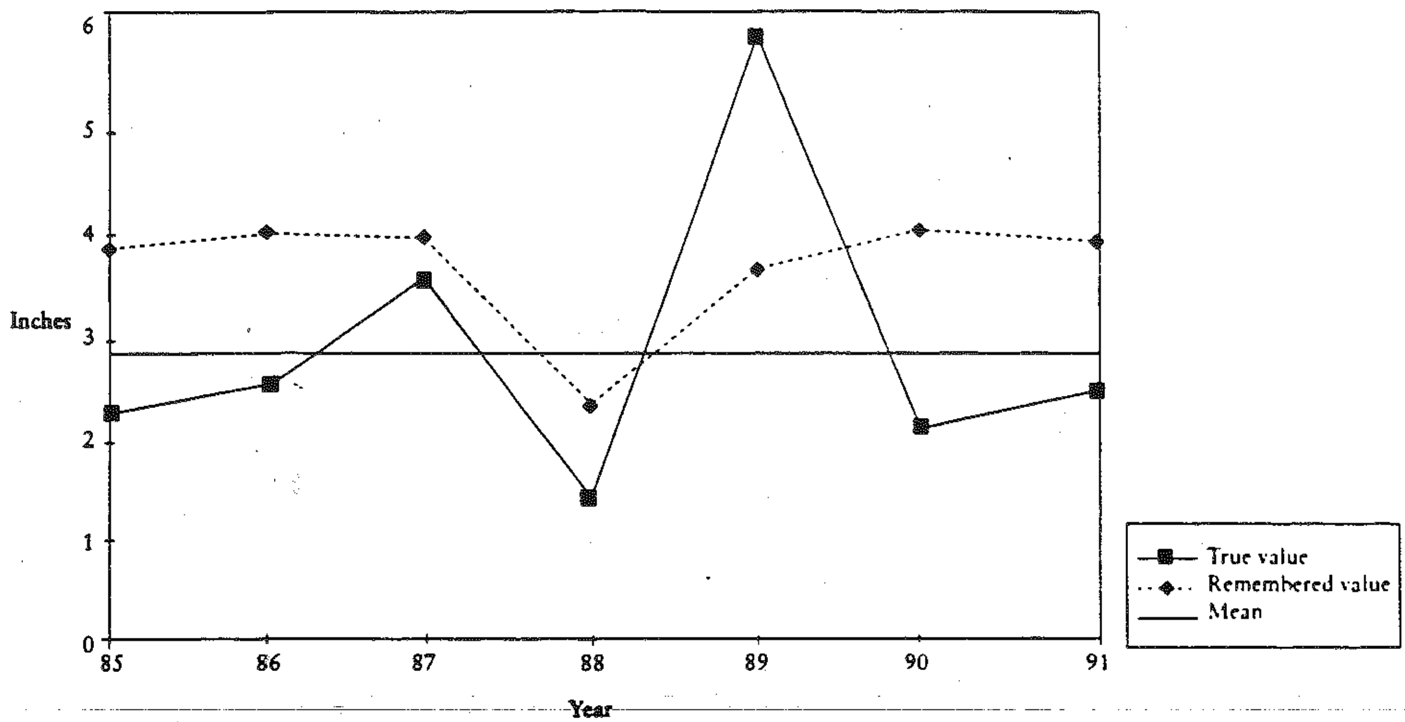

Figure 13.2. True and Remembered Rainfall in East-Central Illinois During July, 1985 to 1991.

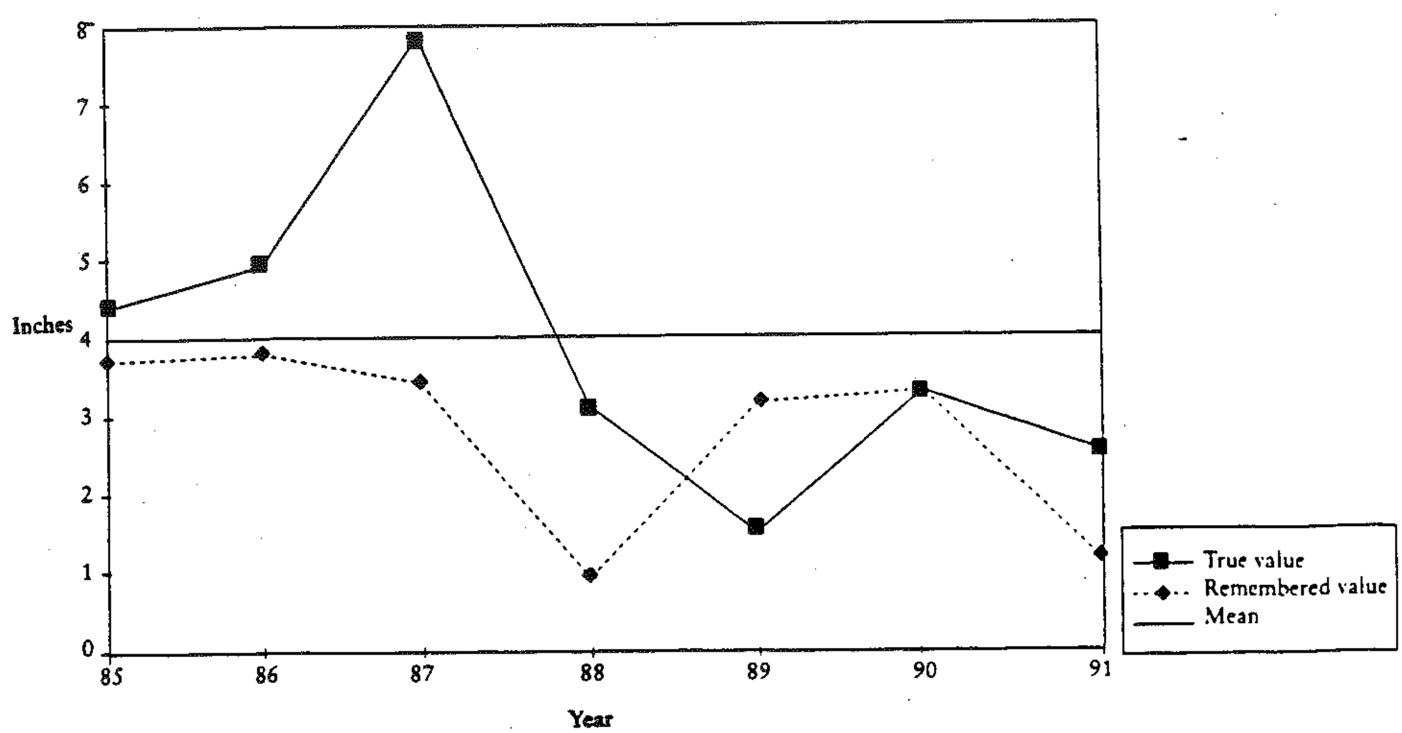

Table 13.5 lists the variables that were significantly correlated with the accuracy of farmers' memories for April and July precipitation, as well as the direction and magnitude of the correlations. Accuracy was defined as the sum of absolute deviations between reported and true values across the two months and averaged across the seven years. More accurate farmers tended to report lower April rainfalls and greater July rainfalls. Three of the management traits described in Table 13.1 were related to the accuracy of precipitation memories; both active experimentation and systematic analysis contributed to accuracy, whereas macromanaging made farmers less accurate. It is worth noting that length of farming experience was *not* correlated with accuracy. On the other hand, disbelief in climate change was positively related to accuracy and belief in the greenhouse effect and ozone depletion was associated with less accuracy. In other words, farmers who believed in climate change were more likely to distort their memories of past precipitation in the direction predicted by climate change models: more precipitation during winter and early spring and less precipitation during the summer (Palutikof, Wigley, and Lough, 1984).

In addition to being asked to generate precipitation memories from the recent past, farmers were asked whether they had noticed any change in average daily maximum temperatures in July over the last five years and, if so, about the direction of such change. Table 13.6 shows the percentage of farmers who remembered the average daily maximum temperature in July to have either stayed the same, increased, decreased, or become more variable over the last five years. (The percentages add up to more than 100 because some farmers' content-coded responses fit more than one category, mostly "hotter" and "more variable.") Sixty-two percent of farmers remembered some change in July temperatures over the last five years, with opinions being evenly divided between temperatures having become either hotter or more variable. Actual temperature data were consistent with both of these changes.

Table 13.5. Correlates of Degree of Accuracy in Rainfall Memories.

Correlation	Variable
+.30	Active experimentation
+.31	Systematic analysis
−.37	Macromanaging
+.34	Disbelief in climate change
−.43	Belief in greenhouse effect
−.41	Belief in ozone depletion

Table 13.6. Respondents Remembering Specified Change in Average Daily Maximum July Temperature over Last Five Years.

	RESPONDENTS (%)		
Remembered Change	*All Farmers*	*Disbelievers*	*Believers*
Same	42	52	27
Hotter*	30	16	54
Colder	2	0	2
More variable*	30	40	17

**Remembered change corresponds to actual change.*

Table 13.6 also shows the distribution of temperature change memories as a function of whether farmers did or did not believe in global warming. There was a significant association between belief in global warming and prediction of July temperature changes (chi-squared (3) = 6.21, $p < .05$). Fifty-four percent of the believers but only 16 percent of the disbelievers in global warming remembered a short-run increase in July temperature.

Effects of Farming Experience

Consistent with theoretical predictions, farmers with more farming experience, who consequently had more experience with random (or nonrandom but cyclical) fluctuations of temperature and precipitation, were less likely to believe in the existence of possible contributors to climate change (that is, the greenhouse effect or ozone depletion) and were also less likely to remember July temperatures over the last five years as evidence of a warming trend. Yet, although the direction of these correlations was in the predicted direction, none of them reached statistical significance. Predictions about the negative effect of experience on farmers' perceptions of a warming trend thus received much weaker empirical support than the theoretical predictions about the facilitating effect of prior expectations.

Behavioral Adaptations Designed to Reduce Climate Risk

Pilot interviews with several farmers resulted in the identification of two classes of behavior that allow for the reduction of the downside potential associated with the possibility of a global and local warming trend. One class of risk-reduction behaviors consists of production practices. Farmers were asked in the survey whether they thought that changing climate patterns would eventually force them to change any of their farming practices. Fifty-two percent of respondents replied in the affirmative and were asked to list those practices and the nature of the change. The most commonly mentioned changes in production practices are shown in Table 13.7. It is interesting to note that a more conventional risk-reduction method, the purchase of crop insurance (or more of it), was listed by only 5 percent of respondents, whereas changes in tilling practice and associated changes in the use of pesticides were mentioned by 72 percent and the use of different (more drought-resistant) varieties of corn by 50 percent. (The percentages again add to more than 100 because farmers were allowed to give more than one response alternative, if so desired.)

The other class of risk-reduction behaviors involves financial responses and concerns the way in which farmers insure and price their crops. Farmers can price a crop before it is harvested and lock into a particular known price either by selling it by a forward contract to a local grain elevator or by hedging against price fluctuations with futures contracts. Alternatively they can assume the price risk themselves and sell the crop

Table 13.7. Anticipated Behavioral Adaptations to Climate Change and Their Determinants.

Adaptation	*Percentage of Responses*
Change in production practice	
Change in tilling practice or pesticide	72
Use of different crops or varieties	50
More irrigation	10
Earlier planting	14
Change in pricing practice	
Greater use of futures market	32
More crop insurance	5
Determinant for change in current pricing strategy	
Supply and demand factors	63
Weather in general and drought in particular	30
Tax reasons	14
Failure of current strategy	12
Cash-flow problems	12

after harvest in the spot market, selling it either all at once or stockpiling it to wait for better prices in the future.

An early part of our questionnaire ascertained to what extent farmers currently used these different pricing mechanisms (16 percent used the futures market and 32 percent used forward contracts), whether they had regular before- or after-harvest pricing strategies as opposed to deciding yearly on an ad hoc basis (25 percent had a regular before-harvest and 21 percent a regular after-harvest pricing strategy), and whether and to what extent they used crop and hail insurance (47 percent used crop insurance and 86 percent used hail insurance; of those who purchased insurance, crop insurers covered an average of 34 percent of their crops and hail insurers an average of 78 percent of their crops).

Anticipated changes in pricing practices most commonly mentioned as responses to possible changes in climate are also listed in Table 13.7. It is obvious that the percentage of farmers anticipating some pricing adaptation is much smaller than the percentage anticipating some production adaptation. Of those who did mention some pricing adaptation, the vast majority expected to make greater use of the futures market.

To understand the causal underpinnings of farmers' pricing strategies, the interviewer asked under what circumstances the farmers would change their current pricing strategies. Their responses, also in Table 13.7, show that although weather circumstances in general and drought in particular were mentioned only 30 percent of the time in a direct fashion, supply and demand factors (which are, of course, very sensitive to weather and drought conditions) were mentioned 63 percent of the time.

In addition to information about anticipated changes in production or financial practices, farmers also provided information about recent or currently ongoing changes in either the decisions or problems they were grappling with, as well as in the solutions to such problems or decisions. Interviews took place shortly before spring planting, and farmers were asked for the three most important decisions related to spring planting that they were currently facing. Their open-ended responses were subsequently content-coded, and three response categories emerged. As shown in Table 13.8, the largest percentage of farmers brought up issues related to climate or physical conditions for all three decisions. When asked how (if at all) these decisions or problems had changed over the last two to five years, about 60 percent of respondents indicated for each of the three decisions that they had not changed. Of the remaining 40 percent, however, the vast majority indicated that the changes were related to new circumstances, which mostly referred to less predictable weather. Last, farmers were asked how (if at all) the solutions to these problems or the way they dealt with these decisions had changed. As also shown in Table 13.8, more than half of the farmers indicated no change. For the remaining farmers, the largest categories of change in their solutions involved changes in farming practice (about 25 percent across the three decisions), followed by changes in information use (about 11 percent).

In summary, Tables 13.7 and 13.8 provide several interesting observations. Fully half of the respondents listed decisions related to climate conditions as foremost in their minds in their current spring planting, and 20 percent reported that the nature of the decisions had changed due to new circumstances. Thus the hypothetical question about anticipated adaptations to possible climate change was not necessarily hypothetical for a good subset of farmers. More importantly, comparison of Tables 13.7 and 13.8 shows that the frequency with which farmers listed particular types of changes as anticipated adaptations was very similar to the frequency with which they mentioned certain issues as important in their current

Table 13.8. Current Changes in Production Practices.

Decision Category and Change	*% of Responses*
Important decisions related to current spring planning	
Related to climate or physical conditions	50
Related to product (fertilizer) or process (tillage) selection	24
Related to pricing or other financial issues	12
Change in decisions or problems over last 2–5 years	
No change in problem	63
Change related to new circumstances	20
Change related to more information	9
Change related to new technology	5
Other change	2
Change in solution to problems over last 2–5 years	
No change	57
Change in farming practice	22
Change in information use	10
Change in equipment	5
Change in product	4
Other change	2

farming practice. Just as pricing decisions were not mentioned very frequently as current concerns (Table 13.8), changes in pricing practices were mentioned far less frequently than other possible future adaptations (Table 13.7).

Relationship Between Beliefs and Behavior

Table 13.9 shows that there were significant correlations between farmers' belief that global warming was a reality and a variety of reported and observed behaviors. Though there was no relationship between beliefs about climate change and keeping weather and climate records (which were kept by only 28 percent of our respondents), farmers who believed in global warming judged long-term climate forecasts (four to six months into the future) to be more important in their spring planting decisions and were more likely to report using both long-term and medium-term (two- to four-week) weather forecasts on a couple of different occasions during the interview. They also were more likely to report changes in their production methods over the last few years, primarily changes in tillage practice and use of chemicals, as well as changes in crops and varieties of seeds. Finally, climate change expectations were associated with some financial decisions. The more strongly farmers believed in the reality of global warming, the more likely they were to insure their crops against hail and crop failure, hedge against price fluctuations with futures contracts, and have a regular before-harvest pricing strategy using forward contracts and the futures market.

Though the correlations between belief in global warming and the five measures of farming success across the seven years of records were mostly positive, they were not significant. An *F*-test of the effect of belief in global warming in a repeated measures ANOVA was also not significant, and analysis of the farming success variables as a time series over the seven years also revealed no significant differences in slope as a function of belief in global warming.

Two additional regularities in farmers' adaptations and responses to the prospect of climate change are worth noting. First, correlations between production adaptations to possible climate change (for example, shifting to crops that use less water) and pricing adaptations (for example, using futures contracts more extensively) were mostly negative across farmers ($r = -.44$, on average). Secondly, there were also significant negative correlations between farmers' likelihood of engaging in risk-reduction behaviors that require some personal initiative (mostly production changes, such as

Table 13.9. Correlates to Belief in Global Warming.

Correlation	*Variable*
.52	Long-term climate forecasts being judged more important
.35	Greater use of medium- and long-term climate forecasts
.33	Climate forecasts used more
.59	Changes in tillage method over last few years
.41	Changes in types of crop
.47	Changes in varieties of seed corn
.40	Greater percentage of crops insured against crop failure
.32	Greater percentage of crops insured against hail
.33	Greater percentage of crops priced by futures
.30	Regular before-harvest pricing strategy

planting more varieties of corn or allocating more acres to experimentation with new varieties, but also some pricing changes, such as developing a different before-harvest strategy) and their support of government interventions designed to reduce carbon dioxide emissions. In particular, farmers were asked to express their support (on a scale from 1 to 10, with the option of expressing no opinion) for three government initiatives: promotion of ethanol, higher gasoline taxes, and restriction of fossil fuel usage. Mean support of these initiatives was 7.3, 3.4, and 4.5, respectively, but more importantly, the less likely farmers were to engage in risk-reduction behavior requiring some personal initiative, the stronger was their support for these government interventions ($r = -.41$, on average).

These results suggest that the farmers in our sample fell into three approximately equal-sized groups with respect to their proactive or reactive responses to climate change. Group one was inclined to support government initiatives to reduce the threat of global warming but less likely to modify either their production or their pricing practices. Groups two and three were less likely to support government intervention but favored personal initiative. Group two was more likely to apply its personal initiative to adaptations and modifications of production practices, whereas group three was more likely to translate its concern and initiative into adaptations and modifications of financial practices.

In order to determine whether the management traits described in Table 13.1 predicted farmers' choice of adaptation response, I correlated indicator variables denoting membership in group one, two, or three with farmers' scores on the seven management traits. Only some of the correlations reached statistical significance (which should be considered in light of the relatively small sample for the purposes of testing for individual differences), but membership in group one (defined by a mean expression of support for the three government policies of 6 or greater) showed the largest positive correlations with belief in collective wisdom ($r = .23$) and macromanaging ($r = .19$). Membership in group two had its highest positive correlation with active experimentation ($r = .26$) and micromanaging ($r = .20$), and membership in group three was correlated with pricing sophistication ($r = .21$) and systematic analysis ($r = .18$). There was no significant association between the type of adaptation response (membership in the three groups) and belief versus disbelief in global warming (chi-squared $(2) = 2.37, p > .10$).

Conclusion

The field study described in this chapter surveyed the beliefs and expectations of a subset of the general population in the United States that can be expected to be closely interested in local and global weather and climate: Illinois cash-crop farmers. It related those beliefs to farmers' perceptions and recollections of weather patterns in the recent past and to their adaptations at the farm level to current and expected local climate change. In this sample of individuals, slightly less than half believed that the climate of east-central Illinois would undergo any noticeable change over the next twenty to thirty years. For those who did, expectations of the nature and magnitude of change were quite close to those of professional organizations such as the IPCC and well within the range of several "most likely" scenarios provided for the American Midwest.

While there was strong support for the hypothesized effect of prior expectations in facilitating the detection of small climate trends, there was little evidence for a negative effect of prior experience with natural weather and climate variability on the detection of small trends.

Expectations of Climate Change: Antecedents and Consequences

Belief in global warming was not associated with age, experience, or level of education, nor with any of the seven management traits. Those who believed in global warming were more likely, however, to mention agricultural newspapers and less likely to mention popular media (daily newspapers, newsmagazines, radio, or television) as having influenced their belief and mentioned a larger number of sources of influence. A range of production and financial practices with the capacity to reduce the negative consequences of climate risk showed significant correlations with farmers' strength of belief in climate change, which is at least consistent with the belief as a causal agent for adaptive responses.

Belief in Global Warming and Farm Success

None of the measures and analyses of farm success over the previous seven years showed a significant effect on farmers' current belief in global warming, even though the vast majority of correlations were nonsignificantly positive. The positive relationship between belief in global warming and farm success may be partially mediated by the fact that the last two correlates of such a belief listed in Table 13.9 are contributing variables to two of the measures of farm success as shown in Table 13.1. In particular, pricing a greater percentage of crops by use of the futures market was found to contribute to operational efficiency, and having a regular pricing strategy was found to contribute to better prices. Though it seems reasonable to assume that these pricing practices causally contribute to farm success, the causal relationship between a belief in climate change and the production and pricing practices found to be associated with such a belief is less obvious and awaits further study.

As the point in time at which farmers started to believe in climate change was not determined in this study—it may have been relatively recent—it is perhaps not surprising that the observed effects of a belief in climate change on the success of the farming operations measured up to seven years into the past were positive but not significant. Even if current adaptations have positive effects on profitability, prices, or yields in the long run, farmers' beliefs and associated adaptations may not extend that far into the past.

Belief in Global Warming and Accuracy of Memories of Past Climate Patterns

The expectation of climate change made it more likely that a small local warming trend was interpreted and remembered as such. Maximum daily July temperatures over the previous five years had been both hotter on average and more variable; however, as shown in Table 13.6, believers in global warming overwhelmingly remembered the former and disbelievers mostly the latter. The expectation of climate change also made farmers less accurate with respect to remembered levels of precipitation over the previous seven years, biasing their memory in the direction predicted by global warming models.

Previous work on the potential value of externally provided weather and climate forecasts for decisions whose outcomes are affected by climate variables has investigated the accuracy levels necessary for short-term weather forecasts (Baquet, Halter, and Conklin, 1976; Lave, 1963) and longer-term climate forecasts (Winkler, Murphy, and Katz, 1983; Brown, Katz, and Murphy, 1986) to have economic value. These studies generally evaluate the value of climate information under the assumption of rational profit maximization and unlimited processing capacity. An exception is a study by Changnon, Sonka, and Hofing (1988), which investigated the value of climate predictions for the seed corn production sector by looking at the allocation decisions of actual seed corn producers in the Midwestern United States made either with or without the benefit of climate predictions. Allocation decisions were entered into an economic model that simulated the stochastic nature of summer growing conditions in the region and calculated the financial outcome of the allocation decision. The analysis documented that predictions of even low accuracy could have potentially large economic value if available with sufficient lead time. This suggests that, given the base rate assigned to the reality of climate change over the next few decades, an expectation of climate change may have economic value even if it is associated with some schema-consistent distortions of climate memories that may possibly reduce the accuracy of internally generated predictions and forecasts.

Individual Differences in Method of Adaptation

The study demonstrated the existence of individual differences in the way Illinois cash-crop farmers reacted and adapted to the possibility of global warming. Related to other differences in management practices, one group of farmers strongly supported government interventions designed to reduce the possibility of climate change but were less likely to modify any of their farm practices, whereas two other groups were less supportive of government interventions but more likely to take personal steps to reduce the downside potential of climate change, with one group relying mainly on production adaptations and the other relying mainly on financial adaptations. Although the current study did not provide any information about the relative success of these different adaptation strategies, it is useful to know that farmers do not automatically employ the full range of adaptive responses, even if they believe in the need for adaptation and change. Instead, individual differences and management style factors seem to predispose them toward certain classes of responses. Engagement in one class of adaptation and risk reduction seems to limit farmers' awareness of other, potentially complementary, risk-reduction mechanisms. This suggests the importance of external aids in the generation of adaptive responses (for example, brochures or checklists) that provide farmers with a full complement of interventions that have the capacity to hedge climate risk.

Summary of Research and Policy Implications

The results and implications of this field study can be summarized as follows.

First, no clear mechanism or set of determinants for a belief in global warming was identified. As such a belief seems to help in the detection and amplification of existing warming trends, it is unfortunate that no more is known about how to foster such a belief. The present study showed, however, that farmers who expressed belief in a warming trend tended to cite more sources as having influenced their opinion than those who did not. Even though this relationship may not be causal, it suggests that up-to-date information about current and projected climate trends ought to be distributed through a wide variety of sources (for example, agricultural newspapers and cooperative extension services). Future research ought to address the following two sets of questions: (1) How general is the relationship between number of influential information sources and belief in global warming? Does it translate to beliefs in other categories of uncertain environmental changes or in other phenomena? (2) Is the relationship indeed causal (in the sense that increased exposure to [confirming] information sources would increase belief in the phenomenon), or is it the result of an individual difference on a third variable that is responsible for both a greater willingness to believe in environmental change and to expose oneself to more sources of information?

Second, and partly as a consequence of the first point, research funds should be allocated to assess the effectiveness of different types of adaptive responses and the determinants of individual differences between farmers in their beliefs and expectations about climate change as well as in their adaptation strategies.

Finally, as argued in the last section, farmers and other individuals faced with potentially consequential environmental change should be provided with external guidance about the full range of adaptive risk-reduction responses available to them. That the present study found that farmers were limiting themselves to one of three classes of risk-reduction

methods has important policy implications. It exemplifies a shortcoming in the problem-solving process that has also been identified in other problem domains: once a solution to a problem has been identified, people tend to stop the search process and, as a result, may fail to generate alternative or additional solutions. Berman and others (1991), for example, found that radiologists often halt their search for abnormalities in radiographs after finding one lesion, leaving additional lesions undetected. A single solution seems to provide sufficient assurance that a problem has been dealt with, and the resulting peace of mind seems to prevent the generation of additional solutions or adaptations. I hope the results of the present study will serve as a reminder to both researchers and policymakers that complex problems tend to have a variety of causes and call for a range of solutions that involve different aspects of the problem. A single cause or solution often needs to be studied in isolation, and it is easy to forget but important to remember that an effective response to a complex problem at either the research or the policy level will involve a concerted effort to integrate insights and proven interventions from a wide range of different perspectives.

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