

Improving the Water Component of an Agricultural Climate Change Assessment :
Issues from the Standpoint of Agricultural Economists

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Abstract

The National Global Climate Change Research Program is supporting appraisals of water and agriculture among others. This paper discusses ways that the agricultural appraisal impact analysis could benefit in terms of improved treatment of water/climate change related issues. The discussion addresses potential improvements regarding treatment of 1) irrigation water availability and use; 2) baseline future for agricultural in terms of water supply and demand; 3) effects of climate variability on agricultural water use. Information is also presented on anticipated procedures regarding water assumptions in the Agricultural assessment.

Key Terms; Economics, Climate Change Assessment, Agriculture, Irrigation, Water use tradeoffs.

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WATER AND THE AGRICULTURAL CLIMATE CHANGE ASSESSMENT :
ISSUES FROM THE STANDPOINT OF AGRICULTURAL ECONOMISTS

The National Global Climate Change Research Program is supporting ongoing efforts to appraise the future effects of global climate change and of the effects of climate variability. This effort is pursuing appraisals in five areas, two of which are particularly relevant to this paper and these meetings -- the areas of water and agriculture. The authors of this paper are heavily involved in the agricultural assessment effort. This paper discusses ways that the agricultural appraisal impact analysis could benefit from improved treatment of water/climate change related issues and the exchange of information with the water assessment. The objective of the paper is to lay out the issues which we believe overlap the two assessments and to stimulate dialogue between the teams on how to improve the treatment of those issues.

We will discuss the intersection of agricultural and water issues from four different viewpoints

- 1) Assumptions about the availability and use of irrigation water has influenced by climate change.
- 2) Assumptions about major shifts in agricultural water supply and use that have characterized previous agricultural assessments that likely will not be addressed in the current assessment but are important future topics.
- 3) Assumptions about the baseline future for agricultural water supply and demand
- 4) Issues regarding the effects of climate variability on agriculture as the concern pertains to water related impacts

Water Supply/Use Assumptions and Previous Agricultural Assessments

In terms of agricultural production and water interrelationships there are several major issues regarding a global climate change assessment.

- 1) How might climate change influence the regional distribution of yields of irrigated crops and their associated water use?
- 2) How might climate change influence the availability of water for irrigation and other uses regionally considering potential differential influences on
 - a) groundwater sources?
 - b) surface water sources?
- 3) How might climate change alter net agricultural water availability due to changes in
 - a) nonagricultural demands for water use
 - b) instream demands for stream ecology, waste dilution, freshwater inflows etc.
- 4) Considering the changes in irrigation demand and water supply, what will happen to agricultural use of irrigated acres and water along with agricultural commodity prices and economic welfare of various participants in agricultural sector?

Numerous agricultural assessments have been done (See the reviews in Adams et al (1998) and Lewandrowski and Schimmelfennig(1996)). A few studies have dealt with ways that climate induced shifts in water availability and crop water demand affect agriculture while addressing the question in point 4 above (Adams et al 1999 present a partial analysis of water related issues and Darwin 1995 does an analysis which contains a highly aggregate treatment). In those studies a number of assumptions were made which could be improved upon. We will focus most of our attention on the

Adams et al 1999 work as that study was done by one of the two authors and provides the most regional detail on water supply in the US. Darwin (1995) was global and treated the US as one region.

In previous national agricultural assessments, a credible job has been done on the first water issue regarding shifts in crop yields and irrigation demands. However while the analyses have made an attempt at handling the second issue of shifting supplies, this is really only been done for surface water issues. The assumptions made with regard to groundwater availability has been crude, namely that the groundwater availability shifts in the same proportion as does surface water. The previous agricultural analyses also embody the assumption that irrigation water is reduced by the same proportion amount by which surface water availability is reduced. This embodies the critical assumption that nonagricultural demands for water will also be reduced proportionally to the water available. However, this assumes away commonly observed phenomena that water may be shifted from agricultural uses to nonagricultural uses reflecting a higher non-agricultural use value of water.

In summary, the agricultural assessment team has the modeling tools to fully treat irrigation acreage, dryland substitution and regional cropping pattern shifts under different scenarios of net water supply to agriculture . However the climate change analyses could be improved by input from the water sector regarding runoff projections, groundwater availability and non-agricultural water demands under a changed climate.

Omitted Water Issues and Agricultural Assessments

There are a number of water related issues have been ignored in past sectoral level agricultural

assessments which will probably continue to be ignored in the current assessment. These include consideration of:

- 1) The way that climate change shifts the seasonality of water availability in comparison with seasonal shifts in crop water demand and the implications that this has for the configuration of water storage and irrigation delivery systems. For example, an earlier melt of the snow pack might require considerably more reservoir storage to meet irrigation demand, or alternatively, would result in much less water available for irrigation than annual runoff estimates would suggest because of the lack of reservoir storage. Similarly a warmer growing season may alter the time which the crop needs irrigation water along with the intensity with which the water is needed.
- 2) The implications of climate induced altered rates of groundwater recharge and depletion for agricultural performance within specific farming systems as well as regional economies. There is the potential to examine this if the water sector could produce scenarios of aquifer depletion. However, this may be well beyond what is possible in the time frame of the first stage of the National Assessment.
- 3) Widespread study of water scarcity induced changes in irrigation delivery system choice and water delivery efficiency.
- 4) Prospects for widespread irrigation in previously unirrigated areas due to climate induced expansions reductions in profitability of dryland farming coupled with increases irrigation water demand in the areas now using supplemental or no irrigation.
- 5) Links between climate change, surface water supplies, irrigation water use, return flows,

water quality and damages due to altered water quality.

Treatment of this general set of issues is likely to require detailed regional studies before any national appraisal can be undertaken. Indeed the Agricultural Sector Assessment is undertaking limited regional studies for water quality problems related to climate change. The agricultural sector assessment will undertake an assessment of possible water quality impacts in the Susqueana River basin and may investigate soil erosion related issues in the Great Lakes/Eastern Corn Belt.

Characterizing the Future – Agriculture and Water

Irrigated acreage and irrigation water usage is on the decline in many areas due to depletion of major aquifers and expanded nonagricultural demand for water. There also have been major adjustments in irrigation technology with more energy and water efficient systems increasingly being adopted. The national agricultural assessment is charged with looking at time periods forty and hundred years distant. An important factor in examining the impact of climate change on agriculture then involves the forces that will reshape the agricultural economy between now and then. Water will obviously be one of these reshaping forces. Many questions can be raised such as:

What will be the availability of ground and surface irrigation water to agriculture?

What will be the intensity which irrigation is needed within agriculture? and

How will the efficiency of delivery systems change in the future?

All of these are relevant in our consideration of the future. Any help from the water assessment teams in characterizing such issues would be useful and would create greater consistency between the Water and Agriculture Sector Assessment.

Climate Variability and Agriculture -- Water Issues

One feature of the design of the national assessment is an emphasis on variability. Within the Agricultural Assessment we plan to consider issues associated with current variability and the limited set of issues regarding potential changes in variability under climate change. In water, this raises a number of issues would conceivably be difficult to address. A short list follows.

- 1) What would be the effects of potential climate change based alterations in precipitation patterns on irrigation water demand? Will the seasonality of precipitation change? Will more of the rainfall come from intense storms as opposed to frontal rain systems?
- 2) What would be the effects of storms or more frequent ENSO events on water supply and demand?
- 3) What are the effects of climate on the variability of water supply and how should variability for water supply be factored into the national agricultural assessment?
- 4) How does the variability of precipitation and water supply contribute to the variability of agricultural production and income across the country?
- 5) Will variability in stream flow affect river transport which is important for many agricultural products?

Assessment Team Plans

A priority for the Agricultural Sector Assessment is to realistically integrate net agricultural water supply scenarios into a national agricultural impacts. The modeling framework we will use represents that nation as 63 separate regions. This allows us to investigate regional implications of changes in

water availability in crop water requirements. Input from the Water Sector Assessment is critical to make the net supply scenarios realistic. Absent such realistic scenarios we will investigate sensitivity to changes in water supply. We will also use work ongoing in regional assessments that concentrate on water availability and water quality issues as they relate to agriculture. At a minimum some cooperation with the Water Sector Assessment team will be needed to assure mutually consistent and acceptable assumptions.

References

- Adams, R.M., B.H. Hurd, S. Lenhart, N. Leary . “Effects of Global Climate Change on Agriculture: An Interpretative Review”, *Climatic Research* 11:19-30 (1998).
- Adams, R., B. McCarl, K. Segerson, C. Rosenzweig, K. Bryant, B. Dixon, R. Connor, R. Evenson, and D. Ojima, “The economic effects of climate change on U.S. agriculture”.in *Impact Of Climate Change On The United States* Edited by R. Mendelsohn, and J.E. Neumann, Cambridge Press, 1999
- Adams, R., McCarl, B., Dudek, D., and Glycer, J.: 'Implications of Global Climate Change for Western Agriculture', *Western Journal of Agricultural Economics* 12(2), 348-356 1988.
- Darwin, R., 1997. World agriculture and climate change. *World Resource Review*, 9, 17-31.
- Lewandrowski, J., and D. Schimmelpfennig. “Economic Implications of climate Change for U.S. Agriculture Assessing Recent Evidence.” *forthcoming Land Economics* 15(February 1999):
- Schimmelpfennig, D., J. Lewandrowski, J. Reilly, M. Tisgas, and I. Parry: 1996, Agricultural Adaptation to Climate Change: Issues of Longrun Sustainability, Economic Research Service, USDA, AER No. 740, USDA, Washington DC.