WESTERN WATER ASSESSMENT

WHITE PAPER

# Socioeconomic Impacts and Adaptation Strategies: Assessing Research on Quantification of Drought Impacts

by William R. Travis and Roberta A. Klein

2012

Western Water Assessment

# Socioeconomic Impacts and Adaptation Strategies: Assessing Research on Quantification of Drought Impacts

by
William R. Travis
and
Roberta A. Klein

associated database located at
http://www.socioeconimpacts.org

Western Water Assessment
and
Center for Science and technology Policy Research
Cooperative Institute for Research in
Environmental Science
University of Colorado
Boulder, Colo.

2012

Research supported by the
Western Water Assessment

LIST OF TABLES

TABLE

## Introduction

In response to a need in the Western Water Assessment (WWA) region[1] for socioeconomic data and tools that can aid climate adaptation strategies, the WWA funded this project, "A Socioeconomic Impacts and Adaptation Strategies Clearinghouse," to create a publicly accessible, searchable database of literature on the socioeconomic impacts of and adaptations to climate variability and change, relevant to the WWA three-state region and beyond. This clearinghouse is located at http://www.socioeconimpacts.org and is described in greater detail in a companion white paper, "Socioeconomic Impacts and Adaptation Strategies: Assessing Research on Drought, Climate Change and Recreation". This white paper discusses literature in the database pertaining to a challenge identified by stakeholders: the need for consistent, informative measures that quantify the socioeconomic impacts of drought so that decision-makers can better plan for and document those impacts.

## The Challenges of Quantifying Drought impacts

Drought, and its various manifestations, is one of the largest – if not the largest – concern about weather and climate impacts in the Interior West. A 2011 Western Governors' Association (WGA) report, "Improving Drought Preparedness in the West," called for improved collection of socioeconomic data "to better understand and quantify the impacts of drought and to inform cost-effective preparedness and response strategies" (p. 4). Although the cost of natural disasters, including droughts, has been rising over the years, calculating and reporting those costs has been problematic. The NRC observed in 1999 that:

> The total economic losses that natural disasters cause the nation are not consistently calculated. Following a natural disaster, different agencies and organizations provide damage estimates, but these estimates usually vary widely, cover a range of costs, and change (usually increasing) through time. There is no widely accepted framework or formula for estimating the losses of natural disasters to the nation. Nor is any group or government agency responsible for providing such an estimate (p. vii).

These observations are still accurate today and are especially relevant to drought. Drought research and policy-makers have struggled to develop useful indicators of drought impacts, as in the "Drought Monitor" and "Drought Impacts Reporter", but the literature we reviewed indicates that gross or net economic effects remain unknown. Quantification of the economic impacts of drought is important because it allows decision makers to document and justify requests for disaster assistance, and to demonstrate and evaluate the benefits of drought mitigation programs: "The benefits of mitigation programs can be approximated by using the estimated costs of the disaster that would be otherwise avoided by the mitigation programs" (Ding et al., 2010, p. 2). But economic impacts from drought are difficult to quantify given the slow onset, lack of a clear beginning or end, lack of visible impacts, nonstructural nature and wide geographical extent of drought impacts, as well as the dispersed accounting and impact assessment methods currently in use (Travis et al., 2011). Riebsame et al. (1991), one of the few studies to attempt to estimate national drought impacts, set the total cost of the 1987-89 drought at $39.2 billion, which included the following:

---

1 WWA is one of several Regional Integrated Sciences and Assessment (RISA) programs funded through NOAA. The WWA region includes Colorado, Utah and Wyoming.

| Expenditure/Loss/Cost | Amount |
|---|---|
| Federal disaster assistance | $4 billion |
| Federal crop insurance + emergency feed assistance | $3 billion |
| Transportation | $1 billion |
| Agricultural output (overall farm production) | $15 billion |
| Energy production costs (hydropower and coal) | $.2 billion |
| Food costs | $10 billion |
| Forests | $5 billion |
| Agricultural services | $1 billion |
| Total | $39.2 billion |

p. 56

This estimate has been criticized both as too high, because it included federal disaster aid and crop insurance and failed to account for the increase in producer income from higher food costs, and too low, because it failed to quantify public water supply, tourism, and recreation losses (Hayes et al., 2004; Ding et al., 2010).

More recently, Hayes et al. (2004) describe an effort to collect nationwide data on the 2002 drought. They observe that the information that was collected was incomplete and inconsistent, and that only a very few sectors and a few states were represented. The authors recommend that the U.S. develop "a comprehensive and consistent methodology for determining economic drought losses across all necessary sectors and scales. This methodology needs to be able to capture the complex nature of drought impacts, including the direct and indirect drought losses" (p. 2).

State level drought loss estimations also encounter difficulties. Luecke et al. (2003) estimate the total economic impacts from the 2002 drought in Colorado at between $1.18 and $1.33 billion. Some of the difficulties of quantifying those impacts include separating losses due to drought from losses due to other factors such as economic cycles or 9/11, and inadequate ways to project future drought-related losses. The authors acknowledge that "much of the loss is too difficult to estimate or won't show up until future years" (p. 13).

Other state drought loss estimates include: Arndt (2002) (agricultural losses from 2001-02 Oklahoma drought estimated at about $480 million); Changnon and Knapp (2006) (describes economic losses from 2005 Illinois drought without estimating total losses), Diersen and Taylor (2003) (revises an earlier estimate of $1.8 billion in 2002 drought damages in South Dakota down to $1.4 billion); Georgia Department of Natural Resources (2001) (estimates potential agricultural impact of 1998-2000 Georgia drought in "the billions"); and Knutson and Hayes (2001) (describes economic losses from 1998-2001 South Carolina drought without estimating total losses). These estimates are based on a variety of qualitative and quantitative estimation methods, and perhaps better reflect the demand for assessment as state managers find themselves pressed to generate loss estimates for disaster relief purposes, more than they do the capability to measure impacts.

A handful of studies attempt to quantify drought economic impacts on specific sectors, for example Hodges and Haydu (2003)(Florida horticulture industry) and Schneckenburger and

Aukerman (2003) (Colorado tourism and recreation). Such focused assessment are presumably more accurate, but they also risk under-counting losses as they spread out from, and reverberate among, sectors.

Two recent review papers, Markandya and Mysiak (2010) and Ding et al. (2010), address some of the methodological difficulties in assessing drought economic losses. Both discuss the need to distinguishing between direct and indirect losses, which is important because the definitions dictate the scope of impacts that will be included. Direct losses have been defined to include land degradation and devaluation, failure of perennial crops, soil degradation, and the physical damage to buildings, landscaping, crops, and natural resources. Direct losses also include the many costs associated with reduced M&I water supply, reduction of farm outputs, drought-forced downturn in tourism, and/or losses due to business interruption. Indirect losses have been defined to include temporary unemployment, depleted savings, decline in investments not related to drought mitigation, drop in national income, opportunity costs of drought-related budget expenditure, or increase in food imports.

After losses have been categorized as direct or indirect, a related problem is how to accurately measure indirect losses, to account for benefits or other off-sets, and then to judge the net loss. Some analysts have suggested that a form of econometric modeling, such as an Input-Output (I-O) model, could be usefully applied. Hazards researchers and weather and agricultural agencies have urged such an approach for decades. One commonly-used I-O model, IMPLAN, which was originally developed by the U.S. Forest Service to project impacts of forest production on the local-to-national economy, has been cited as potentially useful to assessing impacts (its flaws have also been noted, see McKean and Spencer 2003; Ding et al. 2010). McKean and Spencer actually calibrated IMPLAN for Colorado's irrigated agriculture sector and ran it to estimate impacts of the 2002 drought. Ding et al. (2010) support the call for such modeling as one possible method for calculating net drought impacts. Diersen and Taylor (2003) used multiplier coefficients from the IMPLAN data base to estimate indirect and induced effects of drought on the South Dakota economy, though they did not actually run the model.

Additional problems with measuring drought losses pertain to geographic and time scales. Local drought impacts might be balanced out if the analysis is at the regional or national level: "farms outside of drought-hit areas may benefit from higher crop prices; railroads may benefit from reduced water transportations; and the sales of technologies for well drilling, weather modification, and chemicals for suppressing evaporation can be boosted by drought" (Markandya and Mysiak, 2010, p. 133). This was an issue in the Riebsame et al. (1991) assessment. Their inclusion of federal disaster aid and crop insurance payments as costs of drought was problematic because federal payments should be counted as a benefit of the drought if the geographic scale is statewide or below. If the scale is national, the federal payments are a transfer payment and can be ignored as having no net effect, according to Ding et al. (2010). Further, negative impacts might linger for multiple years, raising questions about the appropriate time scale within which to measure drought losses and suggesting a tendency to underestimate impacts in all cases. Similar problems occur in loss assessment for other hazards, like hurricanes or earthquakes, but the acute effects of such hazards, the larger role of private and public insurance, and the immediacy of the impacts and recovery (e.g., loss of electrical power), do tend to make costs (and benefits) more starkly obvious.

Yet another problem is measuring nonmarket losses such as ecosystem degradation, loss of recreational opportunities, and health impacts. While there are methodologies for assessing these kinds of losses they are difficult, expensive and time-consuming and require a high degree of expertise. Further, some losses simply cannot be quantified.

In 2005 the National Drought Mitigation Center (NDMC) launched the Drought Impact Reporter, a web-based tool whose purpose is to provide information on current drought impacts and serve as a national drought impacts database (Wilhite et al., 2007). The Drought Impact Reporter is billed as the nation's "first comprehensive database of drought impacts." Its data sources are voluntarily submitted user reports as well as reports from CoCoRaHS (a nationwide network of volunteers who measure and map precipitation), media reports, formal declarations like burn bans and water restrictions, National Weather Service Drought Information Statements, other agency reports, and "legacy reports" (previously reported impacts).

At this writing, just after the summer of 2012 which was marked by national drought, news coverage of drought is again highlighting the lack of impact numbers, and analysts are calling for better measures. So what approaches might help us evaluate drought impacts more like we do for hurricanes and floods? The Ding and Markandya and Mysiak articles make several recommendations:

- Harmonize different methods of measuring drought losses.
- Standardize and institutionalize drought loss data collection.
- Investigate lagged or dynamic impacts of drought on perennial crops and livestock cycles.
- Develop guidelines for data collection and model utilization that can be customized to accommodate local features.
- Consider non-market losses of drought. Even though the quantification of non-market impacts is difficult and sometimes impossible to obtain, a qualitative description should be available.
- Conduct more interdisciplinary research on the quantitative measurement of drought economic impacts. Economists, meteorologists, hydrologists, and water managers need to work together to obtain a comprehensive assessment of economic impacts of drought.

This wish list recapitulates weaknesses in our assessment capabilities for many natural hazards, but a case can be made that drought can have impacts that are very large, sometimes national, in scope and that are especially hard to measure.

## Discussion

The socioeconomic effects of drought, other types of climate variability, and climate change remain poorly measured. Repeated calls have been made for a standardized drought loss methodology and national database (NRC, 1999; Hayes et al., 2004; Western Governors' Association, 2011; Ding et al., 2010; Markandya and Mysiak, 2010). Yet drought impacts remain less well tracked than, say, flood or hurricane effects, and no centralized database allows comparison of drought costs over time. The National Drought Mitigation Center's Drought Impact Reporter is a step in that direction but some of its reports do not quantify losses and for those that do, it is unclear that the data are comparable over time or place. Most of the reported economic losses are in the agriculture sector with fewer reports of losses in other sectors such as tourism and recreation, business and industry, and municipal water supply.

In terms of overall drought impacts, Travis et al. (2011) conclude that:

Drought impacts are difficult to measure in gross or proportionate terms compared to other extreme geophysical events for several reasons:

- No central database exists for drought losses, with no accepted time series of losses;
- Losses generally do not manifest in injuries, fatalities or obvious property damage;
- Little insurance impact or data exists (outside of agriculture);
- Few “disaster” declarations are issued for drought;
- No unified roster of drought events exists (like the landfalling hurricane record);
- Drought is difficult to define spatially (area affected) and temporally (beginning and end).

## Conclusions and Recommendations

Continued and growing interest in drought and its effects in the West, including for example continuing efforts by the states, federal agencies (e.g., NOAA/NIDIS), and other organizations (e.g., WGA), point to the need to further develop drought impact measures, and link them to drought response options. The literature reviewed here shows the difficulty of measuring drought effects in the aggregate or net, but reiterates the value and need for such an effort. The literature also points to three approaches that deserve more attention:

1. **Vulnerability Studies.** *Conduct more focused geographical or sectoral vulnerability studies like those conducted as part of state drought plans (e.g., the CWCB assessment for Colorado).* Vulnerability studies ask “what if” questions about potential droughts and their impacts. They can point to areas to watch when actual droughts occur, thus offering more efficient and useful monitoring.

2. **Key Indicators.** *Enlarge drought impacts monitoring via a few carefully chosen factors and early warning indicators (rather than the broad-spectrum approach of the drought reporter or the comprehensive approaches often called for in the literature) tuned to specific regions.* Such indicators were examined for the WWA region by Travis et al. (2011). The potential roster of potential indicators is much longer than those so far included in drought impact studies (e.g., yield of indicator crops, water use restrictions, river traffic, retail sales and lodging tax receipts in resorts, hunting and fishing licenses or gear sales).

3. **Impacts Modeling.** *More routine modeling of drought impacts with regional economic input-output models, other types of economic and impacts models, and risk and decision tools, might make more sense than further efforts at comprehensive empirical measurement.* It may be time to answer the long-standing call for applying economic modeling of drought impacts by funding a significant effort to routinely apply economic simulation modeling (an I-O model like IMPLAN) to empirical and hypothetical drought impacts. Models could be used in both prognostic and real-time to assess effects, normalized against regional “benchmark droughts”

(which can be updated), and yielding first-cut estimates of economic loss that might be as accurate as past attempts to count actual impacts and would provide quicker assessment. FEMA has begun to do this with floods and hurricanes, using its HAZUS-MH natural hazard impacts assessment software, which right now does not include drought. Perhaps some of the routines in HAZUS-MH could be modified for quick estimation of drought effects in concert with an I-O model like IMPLAN.

## References

Arndt, D. S. (2002). The Oklahoma Drought of 2001-2002. Oklahoma Climatological Survey Climate Event Summary ES 2002-02.

Changnon, S.A. and H. Vernon Knapp (2006). Societal and Economic Impacts. In The 2005 Illinois Drought. K.E. Kunkel, et al., eds. Information/Education Material 2006-03, Illinois State Water Survey.

Diersen, M.A. and G. Taylor (2003). Examining Economic Impact and Recovery in South Dakota from the 2002 Drought. Economics Staff Paper, December, Department of Economics, South Dakota State University.

Ding, Y., M. J. Hayes, M. Widhalm (2010). Measuring economic impacts of drought: a review and discussion. Papers in Natural Resources.

Georgia Department of Natural Resources Environmental Protection Division (2001). The 1998-2000 Georgia Drought Report.

Hayes, M. J., M. D. Svoboda, C. L. Knutson, and D. A. Wilhite (2004). Estimating the Economic Impacts of Drought. 14th Conference on Applied Climatology and 15th Symposium on Global Change and Climate Variations.

Hodges, A. W., and J. J. Haydu (2003). Economic Impacts of Drought on the Florida Environmental Horticulture Industry. University of Florida, Institute of Food & Agricultural Sciences, Food & Resource Economics Department.

Knutson, K. and M. Hayes (2001). South Carolina Drought Mitigation and Response Assessment: 1998-2000 Drought. Quick Response Report #136.

Luecke, D. F., J. Morris, L. Rozaklis, R. Weaver (2003). What The Current Drought Means For The Future Of Water Management In Colorado.

Markandya, A. and J. Mysiak (2010). The economic costs of droughts. Options Méditerranéennes, A no. 95.

McKean, J.R. and W. P. Spencer (2003). IMPLAN Understates Agricultural Input-Output Multipliers: An Application to Potential Agricultural/Green Industry Drought Impacts in Colorado. Journal of Agribusiness, 21, 2, 231-246, fall.

National Research Council (1999). The Impacts of Natural Disasters: A Framework for Loss Estimation. National Academy Press, Washington, D.C.

Riebsame, W.E., S.A. Changnon Jr., and T.R. Karl (1991). Drought and Natural Resources Management in the United States: Impacts and Implications of the 1987-89 Drought. Westview Press, Boulder, CO, 174 pp.

Schneckenburger, C. A., and R. Aukerman (2002). Economic Impact of Drought on Recreation and Tourism. Colorado Drought Conference: Managing Water Supply and Demand in the Time of Drought, p. 93.

Travis, W., K. Gangwer and R. Klein (2011). Assessing Measures of Drought Impact and Vulnerability in the Intermountain West. Western Water Assessment White Paper no. 9.

Western Governors' Association (2011). Improving Drought Preparedness in the West: Findings and Recommendations from the Western Governors' Association and Western States Water Council Workshops, January.

Wilhite, D.A., M. D. Svoboda, and M.J. Hayes (2007). Understanding the complex impacts of drought: A key to enhancing drought mitigation and preparedness. Water Resour Manage, 21,763–774.