Droughts, Floods and Sustainability

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Introduction

Catastrophic 1993 rainfall and flooding in the Midwestern United States can be viewed in the larger context of achieving regional sustainability. Converging strategies from different sources suggest how we might work cooperatively toward achieving healthy environments and healthy economies, now and in the future, while minimizing losses from natural disasters. These strategies are referred to in terms such as unified floodplain management, multi-objective watershed management, long-term hazard mitigation, ecosystem management, and sustainable agriculture. They involve long-term integrative approaches that include incorporating physical and social science, acquiring reliable information on which to base land use decisions, being able to focus that information at the localities where people live and work on the land, forming partnerships among disciplines and governments at all levels, working with rather than against ecosystem processes, augmenting education and information transfer at all levels, and fostering an ethic of stewardship. Recommendations include (1) setting up demonstration projects within the area of intense 1993 flooding to illustrate ways that flood hazard mitigation and regional sustainability can advance together, (2) showcasing and monitoring exemplary programs that are already under way, and (3) considering such programs as centers of innovation waves and of voluntary adoption of sustainable land management practices. Examples from Iowa programs are cited.

A Look Back, and then Forward

A mere five years before 1993, just a moment in geotime, the nation's midsection suffered from a drought of near record proportions. Lakes and reservoirs were at dangerously low levels, and one could walk across the Des Moines River. Corn and soybean yields were at 5-year lows, and farmers swamped the crisis hot line under the stress of the weather and low returns. During the next few years, weather patterns improved to the point that 1992 gave record grain yields. But farmers' income, although improved, remained low, especially for those whose sole source of income was cash grain.

Thanks to some farsighted federal and state government research, education, and conservation programs, progress was made toward soil erosion control, and even nitrogen fertilizer use was lowered. Some highly erosive land was placed under government control in the Conservation Reserve Program. Still, farm size increased. Land in corn and soybeans remained in corn and soybeans. Virtually no thought was given to possible changes in weather patterns. When will drought return? It was predicted for the summer of 1993, but apparently the predictors did not foresee a stubborn El Nino.

In the fall of 1992, abnormal rains began in Iowa. The rest is history. A state just overcoming the financial effects of drought fought record high water and its devastation. More than twice the normal amount of rain fell during July of 1993. The summer and fall of 1993 recorded the crisis each day in lost housing, destroyed bridges, record low crop yields, and shattered lives. The duration and intensity of the storms rivaled those of the tropics. There was no way to avoid the devastation. Or was there?

Approaches to flood management have changed fitfully over the years -- often influenced by particularly devastating floods -- from reliance on levees and other structural control methods to increasingly comprehensive views that see the flooding river in a broader context of regional environmental systems and human behavior (Myers and White, 1993). An article written just before the 1993 flooding advocated an integrative approach to floodplain management based on local, state, and federal partnerships, citing existing examples variously called greenways, multi-objective river corridor management, and community-based watershed programs (Kusler and Larson, 1993).

In this paper we argue that we should move quickly to consolidate trends toward these comprehensive approaches through demonstration projects. Such projects would illustrate by example the steps that would lead to long-term advances in comprehensive flood management in a context of regional sustainability. Agriculture is a good sector with which to introduce oneself to the field of sustainability, because of its strategic role in the global life-support system and also because many noteworthy advances toward agricultural sustainability have already been made.

Duffy and Lasley (1993) have presented a framework for classifying U.S. agriculture in modern times into two categories, to contrast the predominant view, based on an industrial model, with a newer but growing view, based on a sustainable model (Table 1). We believe that progress toward sustainability could be quantified and monitored in both human and environmental factors by deriving data-collection categories from the distinctions listed in Table 1 and in other similar characterizations. Many practices and stewardship principles in sustainable agriculture as currently defined were common in pre-industrial agriculture a century ago (Williams, 1991).

The landscape that is seen today along Interstate 35, the north-south highway that crosses central Iowa, is far different from what we envisage as a sustainable landscape. The latter would have more diversity, with all highly erodible land covered by vegetation such as productive trees and forages. Waterways would be protected by buffer strips; crucial wetlands to detain runoff would still exist or be restored. A diversity of crops would cover the landscape to slow the water, increase water infiltration, foster biological control of pests, and provide a hedge against crop and income losses due to either too much water, too little water, or other variations in the climate-hydrology cycles. The greater diversity would provide employment and increase the stability and quality of life for the rural community and associated towns and cities.

Grand Experiments versus Transitions to Sustainability

The Midwest floods of 1993 was a record-breaker in many localities in both the amounts of rainfall and the magnitude and extent of flooding. The entire period of Midwest settlement by people of European ancestry before 1993, might be seen as a grand experiment in human-assisted landscape evolution, leading up to the catastrophic events of 1993.

One result of that experiment has been the loss of much of the original topsoil because of land use changes and agricultural practices. Soil erosion and the formation of topsoil are natural processes. However, the acceleration of the rate of soil erosion by our use of the land is widely

Table 1. Two Views of Agriculture

Industrialized View	Sustainable View
✦ Large, capital intensive units and technology	✦ Smaller, lower capital units and technology
✦ Heavy reliance upon external sources of energy, inputs, and credit	✦ Reduced Reliance upon external sources of energy, inputs, and credit (self-reliance)
✦ Specialization (monoculture)	✦ Diversity
✦ Standardized production systems	✦ Locally adapted systems
✦ Vertically-integrated food systems	✦ Local production/regional processing
✦ Fewer farms — higher concentration	✦ More Farms - disperse production
✦ Externalities ignored	✦ Externalities considered
✦ Heavy use of non-renewable resources	✦ Heavy use of renewable resources
✦ Nature consists of resources to be used	✦ Nature is valued for its own sake
✦ Production maintained by chemicals	✦ Production maintained by healthy soil
✦ Emphasis on individualism and independence	✦ Emphasis on community and cooperation
✦ Farming is a business	✦ Farming is both a business and a way of life

Source: Duffy and Lasley, 1993.

recognized as a serious global problem. River-borne sediments delivered to the global oceans are estimated to have increased by 2.5 to 5 times from what they were before agriculture and grazing were introduced (Lal, 1988). In Iowa, average topsoil loss is about 8 tons per acre, and can be as much as 20 tons per acre on tilled, highly-erodible soils (Larson, 1981).

Much of the "lost" soil exists in downslope accumulations near the source, in reservoirs and other impoundments, in floodplains, streams, and the Mississippi Delta. This out-of-place soil costs society in terms of decreased upland productivity and decreased capacity of rivers and flood-control structures (Natural Research Council, 1993). Current soil loss guidelines for practices on which conservation-compliance payments are based are probably too high for a sustainable agriculture (Laflen et. al, 1990). The organic matter in the "lost" upper soils had greater moisture-holding capacity than the underlying soils that became exposed during the years of cultivation. Thus we may hypothesize that the same rainfall that fell in 1993 would have produced less flooding had it fallen on the pristine landscape of 150 years earlier.

How much less? There is evidence that the 1993 flood was more extreme than the precipitation (Luecke, 1993). This line of thinking leads to a series of questions about the water balance of a large flood. In 1993, what pathways did the falling water take from points of impact with the surface to all areas affected by damaging floods? How much water was intercepted by growing vegetation and therefore slowed in its pathway to the ground? After hitting the land surface, how much of the water was further slowed by infiltration into nonsaturated soils? During the period of flooding, how much water was withdrawn from the land surface by evapotranspiration? How much of the falling rain became part of the ground water, and of that how much remained perched above the lowland flooded areas? What percentage of the measured rainfall moved directly over the land surface to the swelling streams, and hòw much soil and absorbed or dissolved chemicals did it take with it? If we knew the answers to these questions about the 1993 flood, could we then calculate the distribution and severity of flooding over a set of different possible landscapes, perhaps representing different stages in the evolution of a sustainable agricultural landscape?

The questions asked in the preceding paragraph suggest a research methodology based partly on the water balance models of Thornthwaite and Mather, and incorporating recent climate change models, geographic information systems, and interdisciplinary modular modeling systems (Leavesley, 1994, unpublished manuscript). Assuming that postflood studies could answer such questions, an even more challenging question presents itself: armed with the knowledge of the likely severity of future flooding and its societal costs, how could a democratic society implement the behavior changes, with their resulting landscape changes, necessary for the transition to regional sustainability? In other words, would it be possible to design and develop a sustainable landscape? Who would consider reconfiguring a highly productive agricultural basin to change it to a sustainable system? How could such changes possibly be made, considering property-rights issues, lack of funds for landowner subsidies, and multigovernment rivalries and deadlock?

We don't have pat answers to these questions, but we do have pathways toward such answers. From the hindsight of today's situation the next phase of the grand experiment could be improved through better use of environmental models, economic analysis, and the associated information necessary to establish quantitative relationships among effects and causes, benefits and costs. We have opportunities, information, and technology not available earlier. Among the opportunities are participating in the many comprehensive activities already under way, variously called sustainability, ecosystem management, unified floodplain management, and long-term hazard mitigation. Some are beginning to acquire the name "transitions to sustainability" (e.g., Faeth et al., 1991; California Institute of Technology, 1992). The actual pathways will not be dictated by scientists or government authorities, but rather will be determined by collaborative actions. Local initiatives, informed by research and comprehensive information resources, will be linked through a variety of communication means to initiatives at regional, national, and global levels.

Initiatives are already under way. At the global level some progress was made at the Rio Conference for Environment and Development (United Nations, 1992). At the U.S. national level the 1990 Farm Bill contained provisions for sustainable agricultural research and education (U.S. Congress, 1990). At the multi-state regional level is the Western Governors' Association Great Plains Initiative (Iowa State University, 1994). An example at the state level is the Iowa Groundwater Protection Act of 1987; among its provisions was establishing the Leopold Center for Sustainable Agriculture at Iowa State University to conduct research, education, and demonstrations, partly funded by fees on the sale of pesticides and other agricultural chemicals (Morandi, 1992). At the multi-county level, in southwestern Iowa a group of farmers and business people formed the Wallace Foundation for Rural Research and Development and raised money locally to purchase a research farm to address the region's particular ecological and socioeconomic problems (Williams, 1991).

At the farm level, a group inspired partly by the Rodale Institute of Pennsylvania banded together under the leadership of Dick Thompson, a farmer living east of Boone, Iowa. They called themselves the Practical Farmers of Iowa (PFI), and the purpose of their organization was to conduct experiments on ways of farming that relied less on capital-intensive farming practices and more on profitable and environmentally-sound farming systems that support the social and economic life of their communities (Sustainable Agriculture Network, 1993). In 1994 after 9 years the organization had more than 400 member farmers who practice sustainable methods and experiment yearly with ways of applying new knowledge to farming.

Many such examples from other parts of the world could be cited. We think these are sufficient, however, to justify a next step, establishing demonstration projects.

Demonstration Projects

Promoting the application of sustainable agricultural practices to flood control is one thing; evaluating (proving) the concept is quite another issue. We recommend that a group of interested agencies join in support of proof-of-concept case studies and demonstration projects.

Projects might be undertaken most efficiently where related information is already available and where there is local support for changing practices in a more sustainable direction. One such area is the Des Moines (Iowa) River valley, which stretches from southern Minnesota to the Mississippi River in Missouri just south of the Iowa border. It contains arguably the richest agricultural land in the world. The soils, formed during the last glacial period 10 to 12,000 years ago, must be tile drained because of their high clay content, but properly treated they are tremendously productive.

The land use in this valley is about 80% cropland, 9% pasture, 3% forest, and 5% urban. The cropland and pasture has a variety of land ownership and stewardship types, ranging from concentrated animal feeding units to diversified farms. Historic data on land and water quality are available (Keeney and DeLuca, 1993). Forest and urban lands, though small in total coverage, are significant in how they affect and are affected by great floods. The July 1993 flood of the Des Moines River and its major tributary, the Raccoon, resulted in the highly-publicized crisis in the city of Des Moines.

A demonstration project might summarize historic environmental and economic trends, assess current land use patterns and practices as related to questions (see above) concerning flood hydrology and water balance, and interview paired sets of Practical Farmers of Iowa members and their neighbors concerning management practices and propensity to change. Finally, the project could recommend future monitoring to evaluate the extent of the region's transition to sustainability and the reduction of future flood losses. Periodic workshops and conferences would permit comparisons of results in other demonstration sites.

Geographic information systems (GIS) capabilities are probably adequate for demonstrations of flood-sustainability relationships. However, land use information sufficiently detailed to distinguish hydrologic characteristics and sustainability is probably scarce. The status of hydrologic modeling also probably is deficient in its ability to account for the heterogeneity of land use and land cover types; however, a proposed cooperative public-private model development activity, an outgrowth of global climate change research, may remedy this deficiency (Leavesley, 1993). In addition, recent studies relating land use and water quality, including some using advanced GIS methods, show promise of possible extension to the flood applications (e.g., Hatfield, 1993; Leavesley et al., 1990; Mueller et al., 1993; Ventura et al., 1993).

Researchers can make use of much of the information that was gathered from long-standing agencies and their programs, such as those of the U.S. Departments of Agriculture, Interior, and Commerce, the U.S. Army Corps of Engineers, the Environmental Protection Agency, the Federal Emergency Management Agency, and other federal, state, and local agencies.

In addition, the Midwest flood of 1993 has generated a high-level U.S. Government interagency Floodplain Management Review Committee that includes a Scientific Assessment and Strategy Team, a River Flows Management Team, a Floodplain Uses and Restoration Team, and new economic analyses. The resulting data and analyses will allow new comprehensive approaches to mitigating future flood losses. The demonstration projects advocated here could benefit from several aspects of this high-level activity, including the intergovernmental collaboration, the data bases on the Midwest flood of 1993, and planned regional workshops, some of which could be conducted jointly with demonstration projects.

In this approach we are advocating the voluntary compliance, non-regulatory philosophy as emphasized in the Iowa Groundwater Protection Act (Morandi, 1992). Therefore citizen involvement in the research and demonstration activities is essential. For example, we would want to ascertain farmer attitudes regarding the relationships of land use to hydrology as it affects the downstream citizens, be they farm neighbors or urban dwellers. And the engine driving transitions to sustainability would be a spatial diffusion process, akin to the classical agricultural extension model. Rogers (1986) gives a definition, critique, and update of the components of this model, including a critical mass of new technology to communicate, a research subsystem oriented to utilization, a high degree of client contact, and a spannable social distance across each interface between components of the system. To evaluate the extent to which this model works in the demonstrations, we recommend careful monitoring of behavior and of resulting landscape changes toward increased sustainability and decreased flood losses.

Would it work? What if appropriate information were provided to the region's citizens before their many individual decisions on management practices and land use? What if true partnerships were to evolve among the citizens who live on the land and the government, academic, and private institutions that have heretofore had fragmented, single-interest approaches to regional management of the land and its wealth of human and natural resources? What if planning for mitigation of future disasters such as floods or droughts were integrated with planning for sustainable agriculture? And what if designing an agriculturally sustainable region were integrated with designs for sustainable forests, families, rural communities, cities, industries, educational systems working toward a healthy economy and a healthy environment, now and for future generations?

Isn't it worth a try?

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