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The 1993 Flood's Aftermath: Risks, Root Causes, and Lessons for the Future

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With losses totaling $19 billion, the record-setting 1993 flood is the second most costly weather-related disaster in the nation's history after Hurricane Andrew with $30 billion (Changnon 2004). The physical, economic, and social impacts of that flood have continued to appear years after the event, and they have inspired investigations into regional flooding, the causes of major losses, and other unresolved issues related to the potential for future flooding. This paper addresses four of these post-flood issues, framed as questions arising in the aftermath of the 1993 flood.

Did the massive 1993 flood losses make the Upper Mississippi River basin the nation's most flood-prone area, and if so, why?

Records of national flood-caused losses show that Iowa's losses lead the nation. Data on flood losses for 1955-1975 were combined with 1983-1997 values, and the three highest-ranking state losses in the Mississippi River basin were Iowa with a total loss of $8.4 billion, Missouri with a total loss of $6.1 billion, and Illinois with a total loss of $5.2 billion (Changnon and Kunkel 2001). Relative to these three states, other Midwestern states had much lower loss ranks.

Many flood losses were concentrated in a few exceptionally damaging floods. To assess the effect of these exceptional floods on state loss values, each state's largest one-year loss value was subtracted from its total losses, and resulting values were re-assessed. The major 1993 flood values were easily the highest for Iowa, Illinois, and Missouri, but when these highest values were deleted from the totals, losses in the three states still ranked highest in the Midwest. Nationally, only Louisiana's losses ranked higher than those for Iowa (ranked second), Missouri (ranked third), and Illinois (ranked fourth).

Flood loss data establish that the tri-state area is where the nation's flood risk is highest. Why is this so? What is unique about Iowa, Missouri, and Illinois that leads to high flood losses? An area's vulnerability to damages from floods is a function of its geophysical setting, social conditions, and hydro-climatic situation. Each of these variables was assessed for the tri-state region and surrounding areas.

One measure of an area's vulnerability to flood damages is the amount of its exposure to rivers that experience major floods. The most flood-prone rivers in the nation include the Mississippi, Ohio, and Missouri rivers. The exposure of all 34 states in the Mississippi River basin to the main courses of these three rivers was ranked, revealing that Missouri, Illinois, and Iowa had the first, second, and fourth greatest exposures, respectively. In addition, the two confluences of the three rivers occur in this tri-state area.

Society's vulnerability to flood damages is a function of land use and value; human occupancy and demographics; and other commercial activities (Pielke 2001). With 104,000 farms, Missouri has more farms than other states in the Mississippi basin, while Iowa's farm frequency ranks second. Farm land values in the 34-state Mississippi River basin show Iowa's values ranked fourth, Missouri's fifth, and Illinois sixth. Thus, the tri-state area is ranked highly in number of farms and value of farmland, both factors involved in flood risk. Population density

also impacts a region's vulnerability to flooding, and Illinois has many more residents than any other state in the basin. The ranks of the three states' population values were 1, 6, and 8 out of the 34 basin states. Flood damages are also enhanced by the extent of urbanized lands. Three of the Mississippi River basin's five largest population centers are in the tri-state area, including Chicago, St. Louis, and Kansas City, and the latter two are alongside these major rivers. Surface transportation is highly vulnerable to major floods, and the nation's leading transportation hubs are Chicago, St. Louis, and Kansas City, which are all located in the tri-state area (Changnon 1996a).

The various weather conditions capable of producing heavy precipitation leading to floods in the Midwest are more frequent, on the average, in Iowa, Illinois, and Missouri than in surrounding states. The tri-state area lies at an intersection of regionally high average values for three flood-critical weather conditions: 1) frontal systems capable of producing moderate to heavy rains persisting over multi-day periods, 2) intense rain-producing conditions lasting a few hours to up to two days, and 3) sufficient snowfall to lead to snow-melt floods.

In summary, the Iowa-Illinois-Missouri area has long been the nation's prime area for flood losses, and this is not the result of the massive 1993 flood losses. A series of geophysical, social, and climatic factors interact to cause flood losses to peak in this part of the Upper Mississippi Basin.

Are flood losses increasing in the Midwest, and if so, why?

The massive losses of the 1993 flood plus ensuing major flood losses in the Mississippi River basin during 1996 and 1997 are indicative of ever-increasing flood losses (Changnon 1998). Midwestern flood data for 1921-1990 reveals systematic, long-term increases in both flood incidences and magnitudes in Iowa, Minnesota, Missouri, and Illinois, but not in the eastern Midwest. Certain precipitation conditions in the Mississippi basin also increased systematically since the 1920s, including upward trends in annual precipitation (5-10%), the number of 7-day heavy rain events (8-15%), and the number of days with precipitation (3-5%) (Kunkel et al. 1993).

Flood losses in the Midwest and nationally also have been increasing systematically since 1930s (Changnon and Demissie 1996). Interestingly, flood losses are the only form of severe weather-related losses to have increased over the past several decades. One factor for the increase in flood losses has been the noted increase in multi-day heavy rainfall events, but the types of extreme rainfall conditions conducive to the flooding that occurred in 1993 and 1997 have not increased. What has also increased notably has been society's vulnerability to flood damages and losses. This includes the growth in population and the growth of wealth vulnerable to flood damage. Demographic shifts to more flood-prone lands along the nation's coasts and to urban areas, which enhance flooding, are other key factors for the increase in flood losses (Pielke and Downton 2000). In the Midwest, urban basins exhibit greater increases in floods than do rural basins.

After the record flood of 1993, many people asked whether human-induced global climate change was to blame. Several hydro-climatic measures of the 1993 flooding matched outcomes expected to occur only once in 100 to 500 years. Some scientists speculated that the expected climate change from global warming would bring about more weather extremes, including flooding. However, the various increases in flood-related precipitation conditions since 1930 are thought to be caused by normal climatic fluctuations, rather than global warming (Changnon 2003a). Importantly, no other types of weather extremes have increased during the Twentieth Century.

What lessons have been revealed by 1993 flood and other recent floods?

In addition to the flood of 1993, two other recent floods illustrate the failure of 150 years of national policies designed to eliminate or mitigate most flooding problems in the Mississippi River basin. In July 1996, a record-setting, 17-inch rainstorm occurred in Illinois, Wisconsin, and Indiana, causing an immense flash flood that covered 12,200 square miles, including most of the western and southern suburbs of Chicago, in a matter of hours (Changnon 1999). In March 1997, a massive flood occurred along the lower Ohio River, inundating areas considered flood-proof in five states and serving as the worst Ohio River flood since 1936. These two flood events and the 1993 flood had several common features that provide six lessons for the future (Changnon 2003b).

Lesson #1: Floods exceeding past experience and design extremes continue to occur. These three extreme flood events caused unusual effects on riverine systems, extreme damage to "containment" structures, unexpected social and economic impacts, and assessments of the "cause" of each event came under scrutiny. Many system failures brought on by the floods were no one's fault—the design values were simply exceeded by conditions never or very infrequently experienced since river records have been kept. To improve understanding, mitigation, and responses to such extreme flooding, several scientific and technical actions are needed.

Lesson #2: Major unexpected impacts occurred. The nation's surface transportation systems—particularly railroads, barges, and highway systems—experienced unusual and extensive damages from these floods (Changnon 1996a). The result was huge economic losses to them and to businesses dependent on them. Second, these major floods enhanced river-floodplain ecosystems, regardless of the human alterations in the floodplains. However, floods also facilitated pest invasions and helped create environmental disasters. For example, the impacts of the nutrients and herbicides swept into the Gulf of Mexico in 1993 and 1997 were sizable. These seemingly odd outcomes reveal current damage estimation techniques are inadequate. Data from these floods should be used to develop better guidelines for estimating flood damage.

Lesson #3: Systems for monitoring and predicting flood conditions failed or were inadequate. Existing systems for monitoring and forecasting floods were found to be inadequate and led to major errors in flood forecasts (Changnon 2000). Better warning techniques and river monitoring systems are needed. Basin hydrologic models used for forecasting need improvement. There also is a need for a layered geographical information system for every river mile to allow better damage estimates as floods develop.

Lesson #4: Flood information was often incomplete, incorrect, or not timely. Information issued on flood conditions and losses was typically poor and generally inaccurate (often on the low side), and loss estimates remained highly inaccurate for a considerable time after the floods. To improve planning for in-flood adjustments and for relief and future restoration activities, means for obtaining more accurate near real-time data on flood conditions and losses should be developed (Changnon 1996b).

There also is widespread public misunderstanding about floods and their frequency. A flood-related educational program would improve understanding of forecasts, warnings, and description of terms used by scientists and engineers, and it would make it easier to recognize the risks of living and farming in floodplains. How flood information is disseminated, and often poorly understood, needs attention.

Lesson #5: Many mitigation approaches failed but some succeeded. Many past structural and non-structural approaches to flood mitigation only partially functioned in these floods. Further, only ten percent of the flood-damaged properties had flood insurance. The floods reinforced the need to make improvements in floodplain use policies and the federal insurance programs. Considerable failure of the levee systems revealed that not all levees, particularly agricultural-protection levees, can be built in a cost-effective manner to withstand major floods (Changnon 2001).

Lesson #6: Floods produce benefits. The major theme of these three floods was extensive losses, but major benefits also occurred (Johnson et al. 2004). Scientists and engineers benefited from new knowledge about floods; certain long-standing environmental problems are now receiving needed attention; most aspects of the river-floodplain ecosystem benefited; inadequate federal policies gained public and political awareness and some improved federal policies resulted; some aged and inadequate infrastructure was flood damaged and is being replaced by better facilities and equipment; and many farmers and businesses in non-flood areas of the United States benefited financially.

What policies were changed or adopted as a result of the 1993 flood?

The uniqueness of the 1993 flood led to the identification of needed changes in the nation's flood policy. Most flood experts realized fifty years ago that structural controls were helpful but not the answer to mitigate losses from major flooding. This realization led to a new policy based on non-structural approaches that change human behavior (e.g., by shifting land uses in floodplains or mandating flood insurance). After the 1993 flood, long-term advocates of this approach recognized that this approach was not successful either. Many argued

that the non-structural approach has been undermined over the past thirty years by ever-growing government relief to flood victims, coupled with inadequate flood and crop insurance programs (Wright 1996).

As the 1993 floodwaters subsided, intensive debates began regarding the range of flood mitigation actions to be considered in flood recovery efforts. Four broad issues were debated, including 1. whether to repair the hundreds of damaged levees, and if so, at whose expense; 2. whether to permit the repair or rebuilding of thousands of substantially damaged structures for future human habitation; 3. assessment of the amount of community planning and financial assistance needed to develop mitigation strategies beyond the typical rebuild and repair scenario; and 4. whether to use the experience of risk (crop and flood) insurance as a mitigation tool.

The federal government's major assessment of the 1993 flood reported that the time was ripe to address future flood-related policies (Executive Office 1994). Major lessons had been taught about every aspect of flooding. In the ten years since the flood of 1993, some lessons have been learned and policies changed. In 1994, changes were made to the National Flood Insurance Program Act and the Federal Crop Insurance Program that lead to increased sales and better coverage as well as less reliance on relief payments. Considerable funding has been spent on restoring damaged levees, but little has been devoted to recommended comprehensive floodplain management practices. The federal program involving buyouts of flooded properties has been successfully employed in over 160 projects. Needed equipment for better flood monitoring has been installed, and flood prediction models have been improved.

However, the lack of action in many key areas reveals the conflicting goals, objectives, and views the nation faces with regard to flood mitigation. For example, such conflicting views and interests are found in the on-going efforts—since 1994—to develop an improvement plan for the Upper Mississippi River basin that can satisfy the widely differing views regarding the navigation system and the ecosystem of the basin. The various controversies and lack of action on many issues shows how difficult it is to balance the economic, social, and political interests of those in the basin and the nation as a whole. The real lesson learned from the 1993 flood, which was a defining event revealing all the issues and problems with existing flood policies, is that it is impossible to accomplish many of the actions needed.

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