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Integrated Planning Information Systems: The Disaster Policy Analysis System (DPAS)

By James E. Moore II with Akram Masri

Planners use and help shape information processing technology appropriate to their tasks. The tools produced by and for this process are planning information systems. Our research integrates knowledge, theory, methods, and technology needed to develop an integrated planning information system for disaster policy analysis.

This Disaster Policy Analysis System (DPAS) prototype evaluates the costs and benefits of Los Angeles earthquake damage mitigation strategies. Net effects are reported across economic and geographic (political) dimensions.

Earthquake and Los Angeles

Estimating site damage from an earthquake depends on the structures involved, the earthquake's magnitude and intensity, and on the site's distance from the epicenter. The Federal Emergency Management Agency (FEMA) provides benchmark estimates of the magnitude, likelihood and consequences of major earthquakes occurring on the various fault systems in California, including the Los Angeles region. (See Tables 1 and 2.)

These aggregate estimates include public and private buildings, but exclude replacement costs of the region's infrastructure and special purpose structures, such as transportation, emergency, and communications facilities, dams, utilities, convention centers and sports arenas.

Disaster Mitigation Policy Analysis

Perceptions of risk and the appropriateness of mitigation efforts vary greatly. The value of a dollar spent today to mitigate an expected dollar lost due to a future earthquake is discounted differently by different individuals, particularly by individuals in different income groups.

The key question for decision makers, including all parties with standing, is not whether a policy provides net social benefits, but who benefits and who loses. At the local level, diverse members of the community are involved, and these stakeholders are affected by these policies in different ways. Policy analysis must address both efficiency and distributional questions. Policy evaluation tools must be understood and accepted by the stakeholders in the context in which the tools are applied.

Our goal is the evaluation of damage mitigation strategies for earthquake disasters. The main problem is to evaluate technical, economic, legal, distributional and political questions regarding various earthquake mitigation policies. The subproblems involve the appropriate system design for this type of knowledge domain, integrating data of different quality from a variety of formal and informal sources, reasoning under uncertainty, and evaluation and validating the system and its outputs. The problem characteristics are incomplete data, an unstructured problem domain, the difficulty associated with de-

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Report Highlights

- This Disaster Policy Analysis System (DPAS) prototype evaluates the costs and benefits of Los Angeles earthquake damage mitigation strategies.
- The value of a dollar spent today to mitigate an expected dollar lost due to a future earthquake is discounted differently by different individuals, particularly by individuals in different income groups.
- The key question for decision makers, including all parties with standing, is not whether a policy provides net social benefits, but who benefits and who loses.

Disaster Policy Analysis System

Tables 1 and 2

Table 1: Predicted Major California Earthquakes

Region	Fault System	Richter[1] Magnitude	Current (Annual)[2] Probability of Event
Los Angeles-San Bernardino	Southern San Andreas	8.3	0.02 - 0.05
San Francisco Penninsula	Northern San Andreas	8.3	0.01
San Francisco Peninsula	Hayward	7.4	0.01
Los Angeles	Newport-Inglewood	7.5	0.001
San Diego	Rose Canyon	7.0	0.0001
Riverside-San Bernardino	Cucamonga	6.8	0.001
Los Angeles	Santa Monica	6.7	0.0001

1 This is the estimated largest magnitude earthquake expected at a reasonable level of probability. The main shock can be expected to be followed by large aftershocks over a period of weeks or longer. Each large aftershock would be capable of producing additional damage and hampering disaster assistance operations.

2 This probability estimate is uncertain by a factor of two to three.

SOURCE: "An Assessment of the Consequences and Preparation for a Catastrophic California Earthquake: Findings and Actions Taken." Washington D.C.: Federal Emergency Management Agency, 1980.

Table 2: Estimated Casualities from Major California Earthquakes

Fault System	Time of Day	Dead[1]	Hospitalized[1,2]
Southern San Andreas	2:30 A.M.	3,000	12,000
	2:00 P.M.	12,000	50,000
	4:30 P.M.	14,000	55,000
Newport-Inglewood	2:30 A.M.	4,000	18,000
	2:00 P.M.	21,000	83,000
	4:30 P.M.	23,000	91,000

1 This point estimate is uncertain by a factor of two to three.

2 Injuries not requiring hospitalization are estimated to be from 15 to 30 times the number of deaths.

SOURCE: "An Assessment of the Consequences and Preparation for a Catastrophic California Earthquake: Findings and Actions Taken." Washington D.C.: Federal Emergency Management Agency, 1980.

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termining validity, and limitations on experts' knowledge. The data involves technical data (urban building stocks, infrastructure, demographics, building and safety, earthquake science, etc.), economic data (construction costs, income groups, etc.), specific legal data (federal, state and local earthquake law and building earthquake safety codes), political data on affected actors, and more general legal data relating to constitutional and distributional questions.

The important concepts are the behavior of different structures at different earthquake magnitudes; the valuation of earthquake damage under status quo conditions, the valuation of the impact of new policies in reducing earthquake damage, the valuation of the private and public costs of policy instruments, the distribution of such benefits and costs across income groups and geographic (political) space, and the evaluation and validation of system outputs.

The DPAS model strategy classifies and recombines available knowledge, recognizing that additional needs will be identified as these tools are tested and used. The core DPAS outputs are summarized in two matrices. The first matrix distributes across 35 planning districts summary changes in public welfare (in terms of dollars) resulting from the adoption of a particular policy. The second matrix distributes these changes in welfare across seven income groups. These matrices describe the net benefits (or costs) of a particular policy instrument. The model's logic flow is summarized in Figure 1.

The model incorporates formal and informal data from diverse sources. Data on urban building stocks by type, cost and distribution are obtained from the City of Los Angeles Land Use and Planning

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DPAS Model Addresses Political Questions

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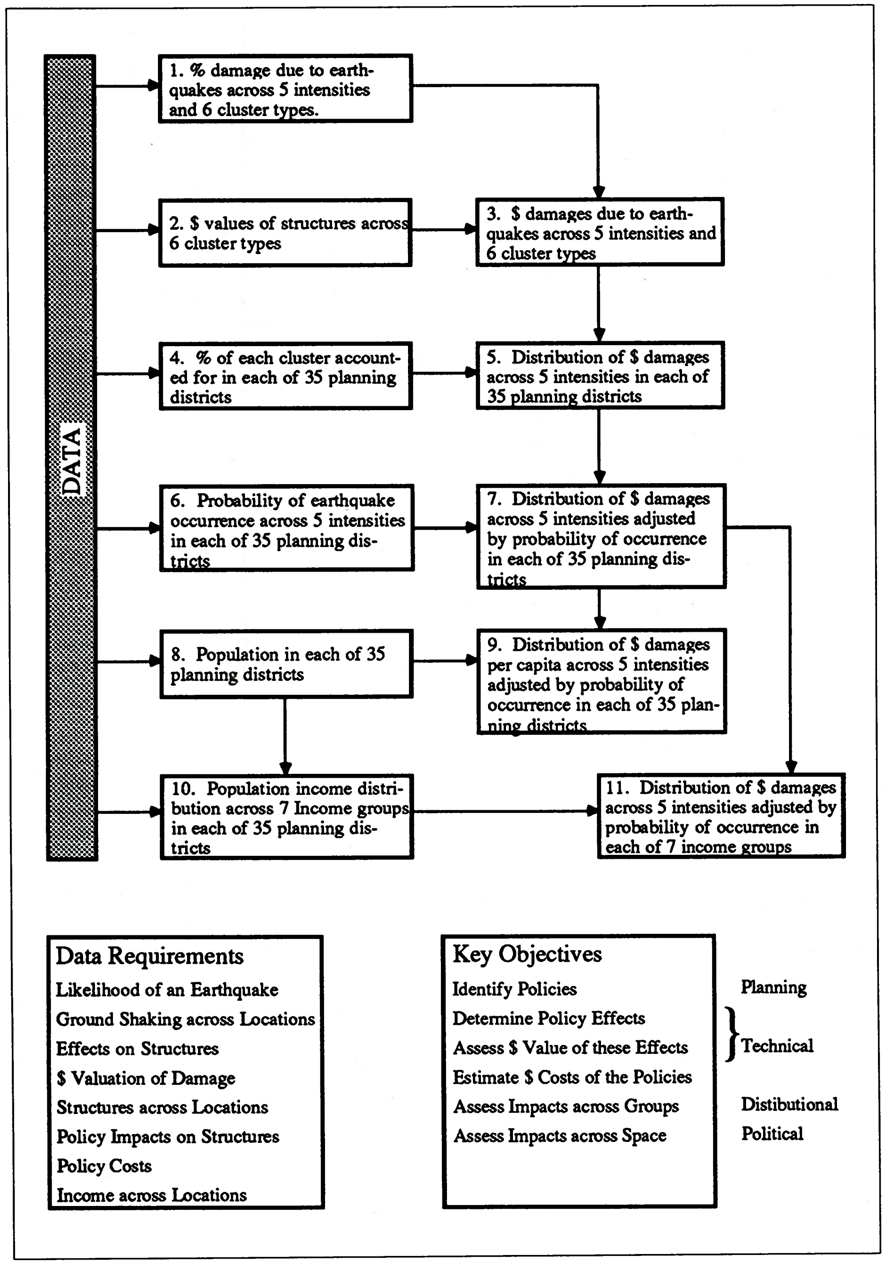
Analysis and Management Systems (LUPAMS) files. Population and income data are obtained from the U.S. Census. Annual risk data for each of 35 analysis zones, with the likelihoods for five levels of ground shaking, are provided by Trifunac and Associates. State and local tax incidence information for individual state income taxes, state sales and gross receipts taxes, property taxes, and local sales and gross receipts taxes allows the researchers to provide a more sophisticated distribution of publicly financed policy costs.

Two key sets of data are not available from formal sources. The first is the expected damage across classes of structure disbursed at different locales, and subjected to different magnitudes of ground shaking. The second is technical assessments of the damage mitigation new policies are likely to achieve. Estimates are constructed for representative classes of structures, disbursed over various geologies, and subjected to probable types and intensities of earth shaking.

We rely on the Delphi technique to estimate damage resulting from earthquakes of various magnitudes. The Delphi exercise provides damage curves for each representative class of structures across five earthquake magnitudes. Discrete versions of these damage curves are used to calculate estimates of expected damage, policy impacts, and the net benefits of mitigation policies.

Figure 1: DPAS Logic Flow



DISASTER POLICY ANALYSIS SYSTEM (DPAS): DPASystem Structure Attributes

The DPAS model is able to identify and integrate required data in a cohesive format, addressing the social and political distributional questions that rational modeling traditionally avoids. It supports the less structured analysis needed in public sector modeling, incorporating formal and informal knowledge, permits trial and error, and provides a platform from which additional model specifications may be undertaken.

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DPAS Consists of Six Components

DPASystem Architecture

DPAS illuminates three traditional elements of policy analysis: economic efficiency, political feasibility and distributional consequences. DPAS processes data inputs from a variety of sources and distributes the costs and benefits of public intervention across different political jurisdictions and economic groups.

The DPASystem architecture consists of six major components. These are:

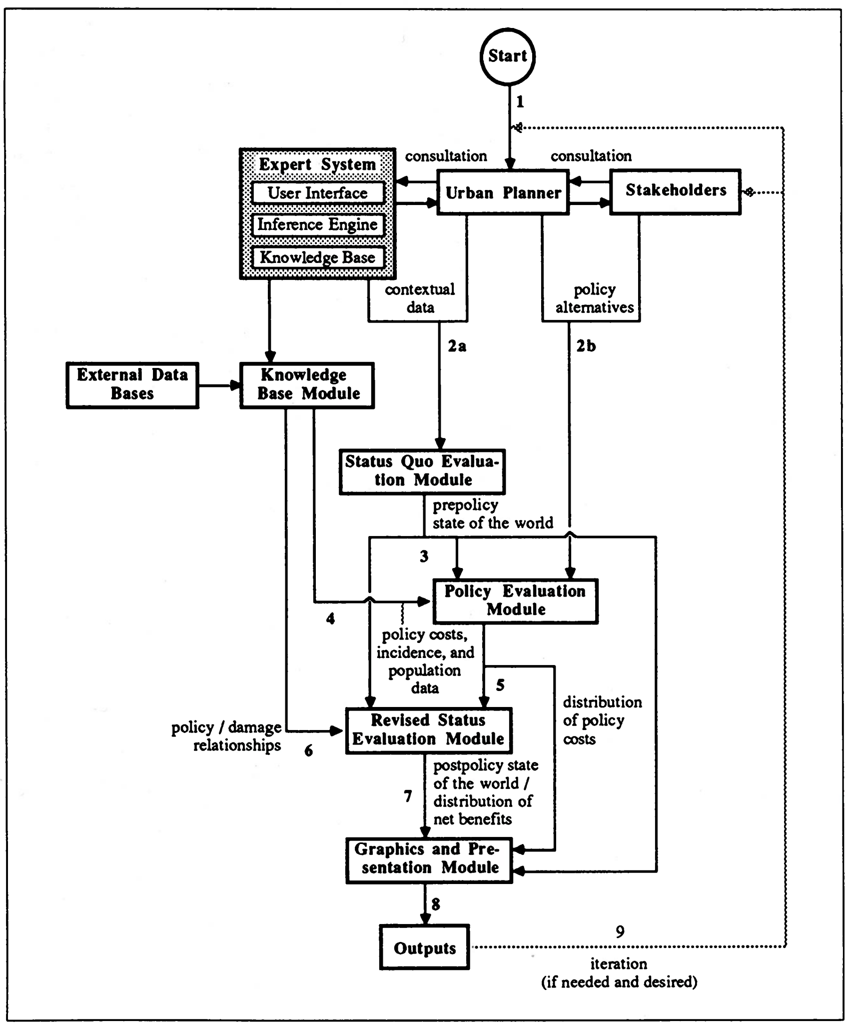
1. the Knowledge Base Management (KBM) module;
2. the Status Quo Evaluation (SQE) module;
3. the Policy Evaluation (PE) module;
4. the Revised Status Evaluation (RSE) module;
5. the Graphics and Presentation (GP) module;
6. the Expert System (ES) module.

DPAS applications proceed according to the flow chart in Figure 2. The system's initial task is to assess the status quo. This is an assessment of the expected event damage prior to the adoption of any new policies. Understanding the causes of disproportionate damage is particularly important.

Outputs include the expected damage to different land use clusters resulting from events of various intensities, and the distribution of these costs over jurisdictions and income groups. The second task is to evaluate prospective policies in terms of damage mitigation, implementation costs, and the distribution of policy costs.

The third task is to evaluate the revised status, that is, the expected damage after the policies are in effect; and to determine the net changes due to damage mitigation policies after accounting for policy cost and cost distribution. Analysis and reporting are supported by the Graphics and Presentation module, which allows for creation of data linked charts, maps, graphical documentation, and online presentations.

Figure 2: DPAS Applications Flow



EXTENSIONS

Evaluation Other Damage

DPAS is designed with the expectation that additions are desired and expected. The system allows for additional modules to evaluate loss of life, injuries, losses to building contents, public facilities and infrastructure, and secondary economic losses.

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DPAS Allows For Add-On Modules

Report Highlights

- In the event of a major disaster, many decisions have to be made in a very short period of time. Extending DPAS' knowledge base to capture decision makers' rules and reasoning provides for wide accessibility of these decision rules when they are most needed.
- DPAS separates the variables into relevant subsets, each of which can be experimented with individually to discover pseudo-Pareto improvements. Policies with such benefit/cost profiles stand a greater chance of political acceptance.

Post-Event Planning

In the event of a major disaster, many decisions have to be made in a very short period of time. Extending DPAS' knowledge base to capture decision makers' rules and reasoning provides for wide accessibility of these decision rules when they are most needed.

Pseudo-Pareto Policy Improvements

Hazard mitigation is more than a technical exercise. It is an intensely political activity. A policy that reduces damage mitigation and produces a situation where all stakeholders are better off is highly desirable. Experimentation and sensitivity tests are commonly used to identify policy implications for stakeholders. DPAS separates the variables into relevant subsets, each of which can be experimented with individually to discover pseudo-Pareto improvements. Policies with such benefit/cost profiles stand a greater chance of political acceptance. ◆

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