# Interdisciplinary Approaches to Regional Risk Reduction Decision-Making

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***Keywords:*** *Interdisciplinary, natural hazards, regional risk reduction*

**EXTENDED ABSTRACT**

Two federal geological surveys, the United States Geological Survey (USGS) and the Geological Survey of Canada (GSC) have initiated projects with similar goals, but have taken different paths. Both agencies aim to provide natural hazard information for the purpose of reducing societal losses and risk and increasing resiliency. Both projects involve experts from multiple disciplines within and outside these agencies to produce an integrated process and product that transforms natural hazard information into estimates of potential physical damages and subsequent social, economic and ecologic consequences. Both seek to accommodate policy and decision-makers who implement strategies to reduce physical damages, prepare emergency responders, and foster recovery.

The USGS Multi-hazards Demonstration Project (MHDP) (Jones et al, 2007) embarked on describing an earthquake scenario and the GSC Pathways project (Journeay et al. 2007) set out to develop a comprehensive framework for hazard risk characterization and risk-reduction planning. We provide an overview of the two projects, the progress to date, and unique accomplishments. Complementary aspects of the two projects are summarized in Table 1. USGS and GSC collaboration allows the two independent projects to enrich each other: Experience from the MHDP earthquake scenario can be transferred to enhance Pathways natural hazard scenario analyses, while the Pathways comprehensive risk characterization and decision framework demonstrates the broader risk framework for the MHDP.

## 1. INTRODUCTION

A key USGS and GSC mission is to provide scientific products to benefit society. The agencies' science disciplines (e.g., geology, hydrology, biology, geography) conduct research to produce natural hazard information for the purpose of informing decisions about reducing societal losses and risks. Regional and community risk analyses, based on natural hazard scientific information, are needed to communicate risk to policy-makers.

Risk analyses can fail if the provision of science and technical information leads to an unwise decision or is not useful to the decision-making process. The U.S. National Research Council study (Stern and Fineberg, 1996) recommends undertaking risk characterization that is decision-driven and directed towards informing choices and solving problems. Typically, decision-makers are many steps removed from the scientists; scientific natural hazard information is transformed into estimates of physical damages and, ultimately, into societal consequences of interest to the decision-maker. The evaluation of a societal risk problem requires a multidisciplinary team that spans scientific disciplines within the USGS and disciplines beyond the purview of the USGS to partners in the engineering, social and economic sciences.

Figure 1 illustrates the components and connections of the interdisciplinary process that transforms scientific information into a risk analysis of natural hazards for decision-making. Natural scientists provide hazard data (location, magnitude and frequency of primary and triggered natural hazard events). They also provide information about geologic, biologic, and hydrologic susceptibility to specific hazards. Community planners provide information about land use including the built environment. The hazard can affect both the natural and built environment to produce physical damages (direct losses) that can be estimated by engineers. Health and social scientists, economists and ecologists evaluate the social, economic, ecologic consequences (including indirect losses) of the potential physical damages and human casualties, following the natural hazard event. There are three types of decisions that can affect direct and indirect losses and other consequences (e.g., shifts in economic activity): 1. Recovery policies and strategies for the region have a direct affect on the speed and type of recovery a region can make (e.g., Olshansky and Johnson, 2007). 2. Emergency response preparedness and capacity affect lifeline repair and service restoration times and lives lost which, in turn, affect indirect losses (e.g., the effect of business interruption on the economy). 3. Loss reduction strategies alter the environment to buffer the elements at risk from the hazard (e.g., building codes, zoning), to reduce the demands on emergency response and the direct and indirect losses. During policy formulation, decision makers can use these predicted direct and indirect losses and other consequences to consider the effectiveness of strategies relative to their costs.

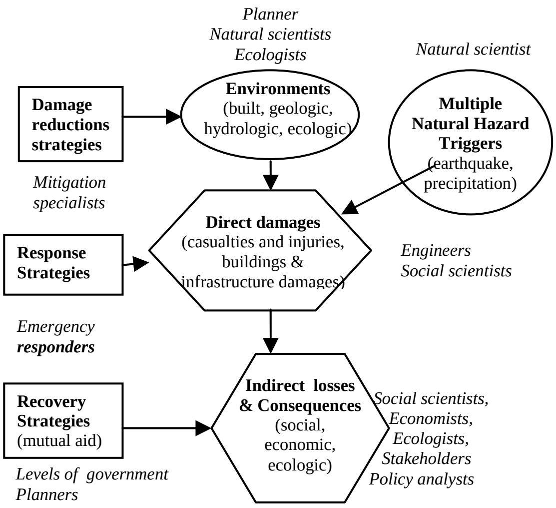


Figure 1. Scope of an integrated science product for decision making and primary expertise for regional risk reduction. Rectangular boxes represent decision options, ovals pertain to physical data and models that direct and indirect losses and consequences in the hexagons

The utility of natural hazard scientific information depends on our ability to integrate and communicate scientific knowledge among scientists and to interface with other disciplines to provide integrated information to stakeholders and decision-makers. Aspects of this problem have been addressed by small groups of interdisciplinary researchers who rely on loss estimator tools (e.g., Olshansky and Wu (2001), or develop tools to expand the capabilities for loss estimation (e.g., Werner et al. (2006) transform hazard science (earthquakes) into highway network performance measures).

Recently, the USGS and GSC have become more proactive about understanding the uptake of and demand for natural hazard information, and developing decision aids for decision/policy-making. The authors (a decision scientist and economist at the USGS) have contributed to two such federal geological survey projects concerned with multiple natural hazard risks and societal resiliency. The USGS Multi-hazards Demonstration Project (MHDP) and the GSC Pathways[1] Project have embraced the interdisciplinary problem encapsulated in Figure 1. Both Surveys are linking experts and tools across disciplines within and outside their agencies to produce an integrated product that transforms natural hazard information into predictions of physical damages and the ensuing societal consequences. Both Surveys recognize the role of policy and decision-makers who implement strategies to reduce physical damages, to prepare emergency responders and to foster recovery.

The independent projects have taken two different approaches to the problem. These approaches are influenced by "stakeholder dominance" and project visionary reference points. MHDP's first product, an earthquake scenario for a state-wide emergency response exercise, was approved and sponsored by the Department of Homeland Security (DHS). This scenario, led by a seismologist, is an in depth study of a single primary hazard (an earthquake) that triggers secondary hazards (landslides, liquefaction and fire) within an eight county region. Pathways set out to address decoupled community planning and risk-reduction planning, and to bridge long term and short term planning. The lead GSC researcher, a field-based research geologist and geoinformatics specialist, is situated within a program to inform decision making for sustainable development, broadly and, risk reduction, particularly. This has led to an approach to support decision making around land use planning in the presence of multiple hazards (particularly, geologic hazards). Pathways approached the problem by evolving a risk characterization and risk-reduction planning methodology for regions exposed to multiple primary hazards. A case study partnership with a small community accentuates Pathways' commitment for the methodology to be co-produced with stakeholders. This reinforces the adaptive and iterative elements in the methodology and contributes to its refinement.

In this paper, we provide an overview of the two projects, and a description of first products, progress to date and unique accomplishments. We highlight the complementary contributions of the

[1] The GSC initiated the work under the Pathways program and continued under "Risk Assessment methods", a revised program on reducing risk from natural hazards. (NRCan)

two projects and propose that continued USGS and GSC collaboration provides the opportunity for the projects to enrich each other.

## 2. USGS MULTI-HAZARDS DEMONSTRATION PROJECT

### 2.1. Overview

The Southern California Multi Hazards Demonstration Project is an interdisciplinary science project that integrates research, information, and science products to improve the usefulness of science and information in reducing loss of life and property from natural hazards (Jones et al., 2007). The project, unique within the USGS, involves examining the cumulative impacts of multiple hazards (earthquakes, tsunamis, fires, landslides, and floods), interfacing with technical expertise outside of the USGS to connect scientific information to damage and societal consequence estimates, and working with diverse community interests on ways they could improve their resiliency to these hazards to prevent a disaster from turning into a catastrophe.

### 2.2. Scope of Work

Four initial priority areas were identified during three workshops attended by regional stake-holders (including USGS scientists, state and local emergency responders, county planners, institutions, businesses and experts): 1. Create tools to integrate spatial and temporal hazard information and expected consequences into risk analysis and decision-making tools that allow stakeholders to postulate and evaluate choices for risk-reduction. 2. Design methods to select and develop planning scenarios and quantify anticipated consequences of future events for emergency preparedness and planning. 3. Improve upon the mapping of multiple urban hazards, relative susceptibilities and risks. 4. Provide real-time information for hazards when knowing the ongoing processes can help mitigate the consequences.

### 2.3. Progress

Project momentum has been paced by funding, and public and private sectors' interest. The MHDP considered the priority areas in a strategy document (Jones et al, 2007). Support from DHS to produce an earthquake scenario for a State-wide emergency response exercise made the project relevant to a range of stakeholders. The opportunity to exercise and stress the emergency response system was welcomed by County emergency responders. Further outreach and media attention expanded the list of partners to over one hundred participating agencies and institutions.

USGS scientists postulated a magnitude 7.8 earthquake along the San Andreas fault, a big event, but historically overdue (Southern California Earthquake Center, 2007). The earthquake (rupture and shaking) triggers secondary hazards including landslides, liquefaction, fire and after shocks. Eight southern Californian counties (Figure 2) constitute the geographic extent of the area most susceptible to the direct effects of the earthquake. A scenario report will contain a regional scale description of the natural hazard event, and examination of damages and societal consequences. The USGS science team recognized that it is impractical to present detailed results across the region; therefore focus studies were identified to demonstrate the potential for analysis at a more detailed scale. The focus studies include several high profile areas: 4 fault rupture crossing points (where there are collocated lifelines), two communities (a desert community in a high shake area, Palm Springs, CA and the midsize city of Torrance in the Los Angeles Basin, CA), and high profile issues including vulnerable building types (e.g., unreinforced masonry), and key economic sectors (e.g., transportation).

The USGS scientist leading the project as the Principle Investigator, decentralized project management by delegating major task responsibilities (hazard events, crossing point impacts, physical damages, emergency response and social, economic and ecologic consequences) to coordinators with expertise in each field.

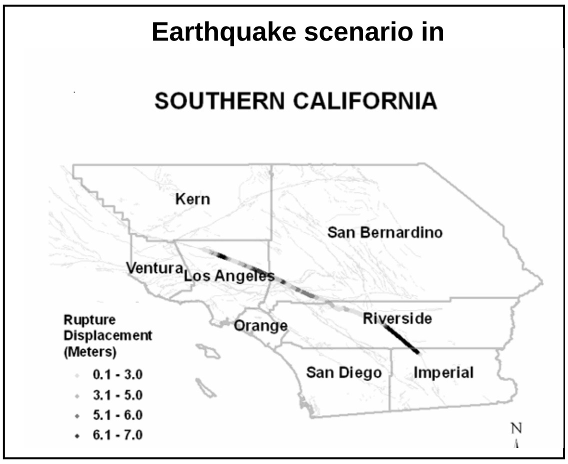


Figure 2. MHDP study area and scope: 7.8 earthquake scenario rupture, shaking, triggered landslides and liquefaction.

Coordinators outlined topics for their area. For example, the economic consequences outline was informed by lessons learned from previous natural hazard scenarios (e.g., Stewart 2005), post event-scenario reports (e.g. IPET 2007, (Petak and Elahi, 2000), feedback from a stakeholder workshop, and expert opinion. The resulting economic consequences outline covers baseline economic conditions, the movement of goods and people and transportation impacts, productivity loss and resiliency of the regional economy, insurance and loans, financial and real estate sectors, and vulnerable businesses. The coordinators contracted experts to assess impacts on transportation sectors, estimate regional resiliency using an economic input-output model, and to reflect on the short term and long term real estate market effects.

Stakeholders have been encouraged to actively participate. The physical damages coordinator set up panels of lifeline operators and experts to verify lifeline damages, downtimes, and interdependencies. The state transportation agency, CALTRANS, is cooperating with the transportation modellers. Invited questions were sent to a financial and banking consortium. Privately owned lifeline companies and institutions expressed concern about releasing confidential information, but they have agreed to provide anonymous and collective responses.

### 2.4. Unique accomplishments

Although the emergency response exercise is the primary driver of the first year task, the USGS is extending its capabilities to provide the "best" scientific information (e.g., not use default data or out of date physical models), to incorporate multiple secondary (triggered) hazards, and to use new scientific methods that are not accommodated in standard damage models (e.g., seismic wave form, long period ground motions). In addition, compared to previous natural hazard scenarios, the MHDP earthquake scenario is accomplishing a more in depth and extensive description of economic consequences, a closer examination of transportation sectors, aggregated input from lifeline operators, an extended view of recovery, and perspectives on policy instruments. The extent of public and private sector involvement and the demand-driven approach to this USGS project is unprecedented.

## 3. GSC PATHWAYS PROJECT

### 3.1. Overview

The GSC Pathways project recognizes a need for tangible and innovative ways for earth science knowledge to be included in decision making for sustainability, while accounting for the nuances of the local and regional context, particularly in areas experiencing rapid population growth or shifts in economic sectors. "Pathways…is addressing these needs by situating and translating earth science information into a form that is compatible with emerging sustainability modelling, planning and decision support frameworks" (NRCan).

### 3.2. Scope of Work

Pathways aims to provide the capacity to: 1. integrate, translate and visualize existing natural and social science information that describe current system conditions for a given geographic region, 2. couple this information with integrated assessment modeling tools to examine both likely and desirable future land use scenarios for a given region, and to assist in the research and development of local, regional and federal policies that will support pathways toward preferred future scenarios, 3. monitor progress toward or away from identified planning objectives using sustainability indicators and related decision-support tools, and 4. engage and involve community groups in the development and use of these approaches in support of specific planning and decision-making functions (NRCan).

### 3.3. Progress

Pathways' progress has been monitored by internal government processes and local council approval of the case study. Before embarking on a case study, Pathways invested time synthesizing the science and policy-making literature, to build a solid philosophical and methodological foundation for community and regional natural hazard risk characterization and planning. The adopted decision-directed analytic-deliberative approach is recommended by authoritative agencies and researchers (e.g., Stern and Fineberg, 1996). A draft document (Journeay et al. 2007) describes Pathways' analytic deliberative framework for regional risk characterization and risk-reduction planning, in Canada, and introduces the District of Squamish case study.

The Pathways analytic-deliberative process defines four stages: problem formulation and risk assessment (risk characterization), and evaluation of alternatives and implementation (risk-reduction planning). Supporting these deliberative stages, the project lead orchestrated experts to customize or develop tools to create a suite of analytic tools with the collective capability to represent future development patterns, estimate physical damages from hazard events, conduct risk analysis and facilitate multi-criteria decision-making. In addition, Pathways prepared an inventory of physical, social and economic vulnerability indicators. The tools and components of the framework have been coordinated by the lead interdisciplinary researcher, a geologist by training.

Pathways set up a case study partnership with the district of Squamish, British Columbia, a small developing community exposed to multiple natural hazards (floods, debris flows, earthquakes). Pathways established a formal agreement with the District of Squamish to ensure that they explicitly commit to reviewing results and committed funds and resources to develop policy informed by the Pathways process. Preparation for the first set of community workshops has entailed: 1. Assembling scientific data flood, debris flow and earthquake events, 2. Designing a risk perception survey. 3. Structuring community workshops for the first stage of the analytic-deliberative framework.

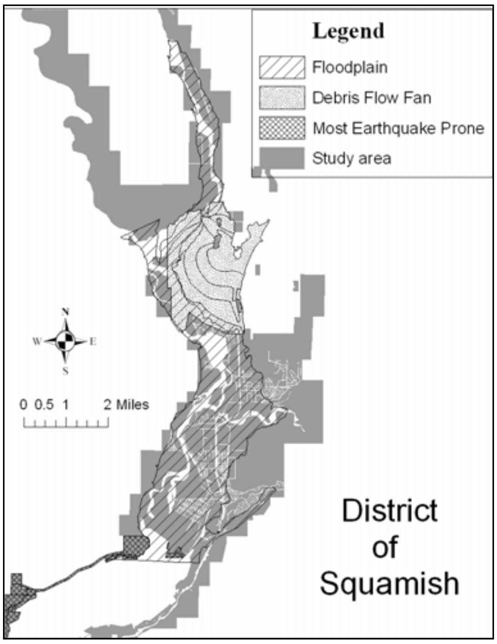


Figure 3. Pathways study area and scope: multiple primary hazards in the District of Squamish. Entire study area is exposed to earthquakes.

### 3.4. Unique accomplishments

Pathways is implementing an analytic-deliberative process that finds the common ground between researchers and practitioners. For example, Pathways is enhancing familiar planning tools (e.g., CommunityViz), contributing to and leading deliberative dialogue processes to identify preferences to guide scenario creation, and preparing to accommodate multiple planning objectives. Pathways has evaluated multiple natural hazards and a range of events within each hazard type, for the municipality of Squamish, providing a unique foundation to develop processes and methods to assess and analyse multiple hazard risks.

## 4. DISCUSSION AND CONCLUSION

The two projects, initiated independently by federal Geological Surveys, embrace common goals and objectives, approach these goals differently, but are otherwise complementary (Table 1). While MHDP has approached the short term perspective of emergency response, Pathways has focussed on the longer term planning problem. Pathways uses scenarios as a building block,, while the MHDP is evaluating a single scenario in more depth and expanding capabilities to incorporate frontier scientific information, engineering estimates, and examination of social and economic consequences. While Pathways is providing a suite of transferable analytic tools, the MHDP has made the interdisciplinary analysis more transparent to the coordinating disciplines. The MHDP earthquake scenario for a region with focus studies has been able to experiment with scale issues (e.g., the trade-offs between spatial detail and descriptive detail), but Pathways has funnelled resources to work closely and more extensively with a community.

The decentralized organization of the MHDP is a delegation of responsibility to coordinating experts across the interdisciplinary process such that the project methodology is emerging as a product of the interdisciplinary collaboration. A network of coordinators participate in a forum to connect the stages of analyses and coordinate the timing, content and format of the information transferred from one stage to the next. MHDP coordinators interface with experts and stakeholders to generate and verify hazard, damage, downtime and consequence results. The open communication has facilitated problem solving as each coordinator pushes on the boundaries of what has been attempted before. A decentralized organization also puts the onus on the coordinators to maintain common project objectives about the schedule and scientific standards.

Pathways, is more centrally organized, such that each collaborator interacts primarily with the lead interdisciplinary researcher,. This has abated scheduling problems, but limited the amount of interaction between interdisciplinary experts and stakeholders. However, the intention is to ensure transferability of the framework through the provision of state of the art tools.

The two project coordination styles raise the issue of managing interdisciplinary projects. This point is still under discussion between the USGS and GSC, but funding and institutional factors appear to explain some of the project organization choices. Significantly higher funding levels has enabled the MHDP project to create a network of experts that can allocate time to the project. The experts are engaged in describing a particular natural hazard event, a more bounded problem than Pathways is undertaking. The USGS MHDP project is also more institutionally incremental in its approach, compared to Pathways, albeit in two directions: the integration of scientific disciplines within the USGS and an expansion of outlook that transforms science into societal consequences. The Pathways project has tackled the need for science to enable risk characterisation and inform planning more directly and more comprehensively, but has required a greater shift in the way the GSC frames its work, such that project support has been more tentative.

Our experiences with the two projects are complementary. We feel that we can produce a better, vetted, interdisciplinary product when we operate as a decentralized organization with expert coordinators contributing the knowledge and experience of their field. On the other hand, we endorse the Pathways approach to address the bigger picture, develop processes and products to

| | MHDP | Pathways |
|---|---|---|
| **Common Overarching Goal** | Regional risk reduction and increasing societal resiliency | |
| **Common Objectives** | Provide integrated interdisciplinary products for decision makers to examine policies to reduce physical damages, prepare emergency responders, and foster recovery | |
| **Project lead** | Seismologist, USGS Earthquake Program | Geologist, GSC Hazards Program (science for sustainability planning) |
| **Stakeholder dominance** | Emergency responders | Community comprehensive & sustainable planners |
| **External Funding** | Funding from Department of Homeland Security/Federal Emergency Management Agency, Southern California Earthquake Center, California Geological Survey, Seismic Safety Commission | |
| **Project momentum** | Bolstered by leadership personality and media attention, regional workshops and outreach, and local and state government involvement | Monitored by agency approval processes (multiple levels of government approval) and a cooperative agreement with the community |
| **First product** | Scenario for emergency response exercise: A large, but plausible natural hazard event translated into damages and consequences, advancing and extending interdisciplinary research | A high level risk and decision-making framework for comprehensive planning, broadly applicable, validated with one community facing multiple hazards. |
| **Inclusion of multiple natural hazards** | Primary hazard with multiple secondary/triggered or correlated hazards | Multiple primary hazards |
| **Case Study Area and scale** | Regional (8 counties) with focus studies (rupture lifeline crossing points, two communities, vulnerable building types and transportation network) | Formal agreement with a small community (population of approximately 15,000) in a fast growing region |
| **Project underpinning** | Subject expertise, Public and private support | Theoretical and empirical foundation, community interest enhanced by recent hazard events and rapid population growth |
| **Project coordination** | Decentralized coordination | Centralized coordination |
| **Scientist experience** | Interdisciplinary research environment with stakeholder input to build an integrated product, a natural hazard scenario (a single point of consideration) | Methodological emphasis supports interdisciplinary tool development for risk analysis (the larger policy and regulatory context) |

Table 1. Summary of USGS MHDP and GSC Pathways projects: the discussion points were selected to highlight similarities and complementary attributes.

prioritize where effort should be expended and provide decision support tools. Under Pathways, we have been able to develop the methodology for multiple hazard risk analysis given a range of primary natural hazard scenarios (that are less detailed than the MHDP earthquake scenario). USGS and GSC collaboration provides the opportunity for the two independent projects to enrich each other: Interdisciplinary research experience of the MHDP can be transferred to enhance Pathways natural hazard scenario analyses. The Pathways analytic-deliberative framework demonstrates the broader horizon of risk characterization and risk-reduction planning to the MHDP.

**Acknowledgements**

We thank Sonia Talwar for engaging in further discussion and her insightful feedback, and Paul Hearn and two anonymous reviewers for their suggestions to improve our presentation.

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