Assessing Geologic Hazards and Risks

Types of Hazards

GEOLOGIC HAZARDS

They include earthquakes, volcanic eruptions, floods, landslides, and other processes and occurrences.

They are included in the broader concept of **Natural hazards**.

NATURAL HAZARDS

In general, natural processes are labeled "hazardous" only when they present a **threat to human life**, **health**, or **interests**, either directly or indirectly, such as locust infestations, wildfires, and tornados, in addition to geologic hazards.

RAPID ONSET HAZARDS

They are ***natural hazards that strike quickly and with little warning and with devastating consequences*** such as earthquakes, flash floods, or sudden windstorms.

TECHNOLOGICAL HAZARDS

It is a different category of hazards ***associated with everyday exposure to naturally occurring hazardous substances***, such as radon, mercury, asbestos fibers, or coal dust, ***usually through some aspect of the use of these substances in our built environment***.

ANTHROPOGENIC HAZARDS

It is another type of hazard ***arises from pollution and degradation of the natural environment***, which have led to problems such as acid rain, contamination of surface and underground water bodies, depletion of the ozone layer, and global warming.

Types of Hazards' Effects

PRIMARY EFFECTS

They result from the event itself. Examples include water damage resulting from a flood; wind damage caused by a cyclone; the collapse of a building as a result of ground motion during an earthquake.

SECONDARY EFFECTS

They result from hazardous processes that are associated with, but not directly caused by, the main event. Examples include forest fires touched off by lava flows; house fires caused by gas lines breaking during an earthquake; and disruption of water and sewage services as a result of a flood.

TERTIARY EFFECTS

They are long term or even permanent. These might include the loss of wildlife habitat or permanent changes in a river channel as the result of flooding; regional or global climatic changes and resulting crop losses after a major volcanic eruption; or changes in topography or land elevation as a result of an earthquake.

Vulnerability and Susceptibility

It is a **concept** that **encompasses**

the physical effects of a natural hazard

as well as

the status of people and property in the area.

Factors that can increase one's vulnerability to natural hazards, especially catastrophic events include:

- Population density
- Living in a hazardous area
- Scientific understanding of the area
- Construction styles and building codes
- Public education and awareness of hazards
- The availability and readiness of emergency personnel
- Cultural factors that influence public response to warnings
- The existence of an early-warning system and effective lines of communication

Human intervention in the functioning of natural systems can increase vulnerability in two ways:

1. Through the **development** and **habitation** of **lands** that are **sensitive** or **susceptible** to **hazards**

(e.g., floodplains or deltas).

2. By **increasing** the **severity** or **frequency** of **natural hazards**

(e.g., overintensive agriculture leading to increased erosion; mining of groundwater leading to subsidence; or global climatic change leading to increased intensity of tropical cyclones).

Assessing Hazards and Risks

In order to incorporate **knowledge about natural processes** into the **planning of human activities**, we have to **assess** the **hazards** and **risks** associated with them.

Although the terms hazard assessment and risk assessment are often used interchangeably, they are not synonymous.

Hazard Assessment

Hazard Assessment is the process of determining

When and **where**
hazardous events have occurred in the past

Severity
of the physical effects of past events of a given magnitude,

Frequency
of events that are strong enough to generate physical effects

What
a particular event would be like if it were to occur now, in terms of the type of effects it would have

Portraying
all this information in a form (often as maps) that can be used by planners and decision makers.

Risk Assessment

Risk is a concept that denotes a potential negative impact that may arise from some event

It is the process of establishing the

Probability
that a hazardous event of a particular magnitude will occur within a given period and its
Impacts

Taking into account

1. **The locations of buildings, facilities, and emergency systems in the community,**
2. **The potential exposure to the physical effects of the hazardous situation or event, and**
3. **The community's vulnerability – that is, potential loss of life, injury, or loss in value – when subjected to those physical effects.**

Risk Elements

Risk Assessment involves establishing the probability and characterizing the physical effects of natural hazards as well as incorporating social and economic considerations such as location, exposure to effects, and vulnerability.

How Risk Assessment differs from Hazard Assessment?

Hazard Assessment

Focuses on characterizing the ***physical effects*** of a particular event

Event occurrence in the history

Severity of these events

Frequency of these events

Frequency of these events

Risk Assessment

Evaluation of the economic losses, injuries and deaths resulted from specific hazard

incorporates ***social*** and ***economic*** considerations in addition to the ***scientific*** factors involved in **hazard assessment**.

focuses on the ***extent of the damage*** anticipated, ***control*** or ***mitigation of the damage***, and actions that might ***reduce vulnerability***.

Probability

Cost

Prediction

Prediction
is a statement of probability based on scientific observation.

Monitoring
usually focuses on identifying *anomalies* that might be precursors.

Precursors
are small physical changes leading up to a catastrophic event.

Accurate prediction requires the continuous monitoring of geologic processes.

Precursor

Observation

If more signals are noticed

About precursor

A prediction can be made regarding the triggering of the hazard

For example,

Before **Mount Pinatubo** in the Philippines erupted violently in 1991, scientists **observed** a variety of **precursor** events, of which the most important were

increases in the number and intensity of earthquakes in the area

changes in the quantity and composition of gases mitted by the volcano

Careful **monitoring** of trends in **precursor** phenomena allowed scientists to **predict** the time of eruption with great accuracy, saving many thousands of lives.

Forecasting

Sometimes the term **forecast** is used synonymously with **prediction**; in other contexts, it is used quite differently.

For example,

In the **prediction** of **floods** or **hurricanes**, **forecasting** generally refers to ***short-term prediction*** of specific magnitude and time of occurrence of an event (days or hours ahead of time, rather than months of years).

In the **prediction** of **earthquakes**, the term **forecast** is generally used to refer to a ***long-term, nonspecific statement of probability***.

For example,

Before the Loma Prieta earthquake of October 17, 1989, the United States Geological Survey had issued a **forecast** indication a **50% probability** of a large earthquake occurring along the San Andreas fault in the region of Santa Cruz **within 30 years**.

This was a relatively *nonspecific long-range forecast based on general scientific understanding of seismicity and the geology of the area, rather than on the observation of specific precursor phenomena*.

Early Warning

The final step in preparing a community to deal with a **hazardous event** is the issuance of an **early warning**.

A **warning** is a ***public declaration that a normal routines of life should be altered for a period of time to deal with the danger posed by the imminent event***.

Warning depends heavily on

- ***Timelines***
- ***Credible sources***
- ***Effective communications and public information systems***

If a warning is issued prematurely or irresponsibly and the event does not occur as predicted, the results can be disastrous.

Like the boy who cried ***"Wolf!"*** *the scientists may be unable to regain credibility, the public may be slow to respond to a real threat.*

Response and the Role of Geoscientists

Some **natural hazards**, such as meteorite impacts, are **impossible to prevent** and **very difficult to predict** within any useful time frame.

Although we know that such an event might occur, there is virtually nothing we can do with current technologies to decrease the **risk**.

There is a **strong need** on the part of the general public, especially decision makers, for knowledge concerning geologic hazards.

Unfortunately, there are many gaps between

The acquisition of scientific knowledge about **hazardous processes**

The effective transfer of this information to people (decision makers)

In order to

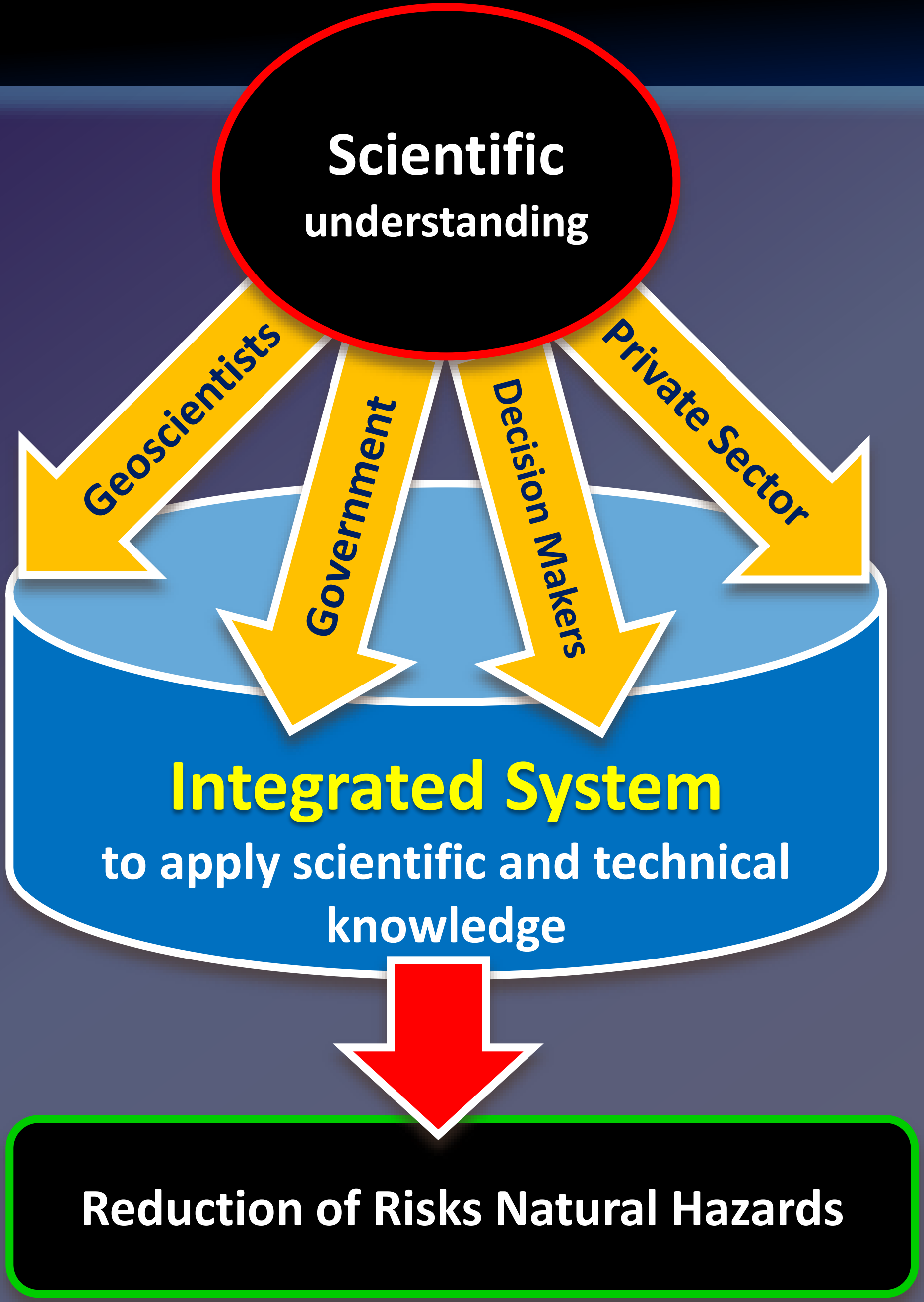
Formulat plans and adopting policies for the reduction of **hazards** and **risks**.

Scientists are concerned with observing and understanding natural phenomena.

A **government official** is likely to be more concerned with the socioeconomic implications or with the feasibility and cost of hazard reduction strategies.

Scientists typically communicate through technical papers, which are published in scientific journals and use specialized terminology

Few **government officials** have the training or the time to keep up to date in the areas of study that are relevant to the management of natural hazards


Scientific
understanding
Geoscientists
Government
Decision Makers
Private Sector
Integrated System
to apply scientific and technical
knowledge
Reduction of Risks Natural Hazards

An integrated approach to the management of landslide hazards

Technical research

Investigate geologic conditions, landscape history, and physics of landslide processes

Gather knowledge about landslide mechanics, triggers, recurrence, and rates

Develop methods to delineate landslide hazard

Federal government and academia

Basic research, national delineation research, and implementation co-ops

State government

State delineation and land-use planning, project review, grading codes, legislation, disaster planning and response

Regional government

Regional delineation and land-use planning, project review

Local government

Local delineation, land-use planning, project review, grading codes and hillside ordinances, disaster planning and response

Private sector

Layout design of projects, engineering correction of slopes

Landslide mapping

Show areal extent, kind of process, and severity of landsliding by landslide inventories and susceptibility maps at state, regional, local, and site scales

Hazard reduction

Provide real-time warnings of potential landslide disasters

Avoid hazard by land-use planning and site design

Discourage development in landslide-prone areas

Legislate grading codes and hillside ordinances to regulate development in landslide-prone areas

Modify slopes or stabilize landslides

Determine location, kind and likelihood of landslide occurrences