EENS 3050	Natural Disasters
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Natural Disasters & Assessing Hazards and Risk	

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Natural Hazards and Natural Disasters

A natural hazard is a threat of a naturally occurring event will have a negative effect on humans. This negative effect is what we call a natural disaster. In other words when the hazardous threat actually happens and harms humans, we call the event a natural disaster.

Natural Hazards (and the resulting disasters) are the result of naturally occurring processes that have operated throughout Earth's history.

- Most hazardous process are also Geologic Processes.
- Geologic processes effect every human on the Earth all of the time, but are most noticeable when they cause loss of life or property. If the process that poses the hazard occurs and destroys human life or property, then a natural disaster has occurred. Among the natural hazards and possible disasters to be considered are:
    - Earthquakes
    - Volcanic Eruptions
    - Tsunami
    - Landslides
    - Subsidence
    - Floods
    - Droughts
    - Hurricanes
    - Tornadoes
    - Asteroid Impacts
- All of these processes have been operating throughout Earth history, but the processes have become hazardous only because they negatively affect us as human beings. **Important Point -** ***There would be no natural disasters if it were not for humans. Without humans these are only natural events.***
- Risk is characteristic of the relationship between humans and geologic processes. We all take risks everyday. The risk from natural hazards, while it cannot be eliminated, can, in some cases be understood in a such a way that we can minimize the hazard to humans, and thus minimize the risk. To do this, we need to understand something about the processes that operate, and understand the energy required for the process. Then, we can develop an action to take to minimize the risk. Such minimization of risk is called ***hazard mitigation***.
- Although humans can sometimes influence natural disasters (for example when poor levee design results in a flood), other disasters that are directly generated by humans, such as oil and toxic material spills, pollution, massive automobile or train wrecks, airplane crashes, and human induced explosions, are considered technological disasters, and will not be considered in this course, except when they occur as a secondary result of a natural disaster.

- Some of the questions we hope to answer for each possible natural disaster are:
  - Where is each type of hazard likely to be present and why?
  - What scientific principles govern the processes responsible for the disasters?
  - How often do these hazards develop into disasters?
  - How can each type of disaster be predicted and/or mitigated?

As discussed before, natural disasters are produced by processes that have been operating since the Earth formed. Such processes are beneficial to us as humans because they are responsible for things that make the Earth a habitable planet for life. For example:

- Throughout Earth history, volcanism has been responsible for producing much of the water present on the Earth's surface, and for producing the atmosphere.

- Earthquakes are one of the processes responsible for the formation of mountain ranges which which direct water to flow downhill to form rivers and lakes.

- Erosional processes, including flooding, landslides, and windstorms replenishes soil and helps sustain life.

Such processes are only considered hazardous when they adversely affect humans and their activities.

Classification of Natural Hazards and Disasters

Natural Hazards and the natural disasters that result can be divided into several different categories:

- Geologic Hazards - These are the main subject of this course and include:
  - Earthquakes
  - Volcanic Eruptions
  - Tsunami
  - Landslides
  - Floods
  - Subsidence
  - Impacts with space objects

- Atmospheric Hazards - These are also natural hazards but processes operating in the atmosphere are mainly responsible. They will also be considered in this course, and include:
  - Tropical Cyclones
  - Tornadoes
  - Droughts
  - Severe Thunderstorms
  - Lightening

- Other Natural Hazards - These are hazards that may occur naturally, but don't fall in to either of the categories above. They will not be considered to any great extent in this course, but include:
  - Insect infestations
  - Disease epidemics
  - Wildfires

Natural Hazards can also be divided into ***catastrophic hazards***, which have devastating consequences to huge numbers of people, or have a worldwide effect, such as impacts with large space objects, huge volcanic eruptions, world-wide disease epidemics, and world-wide droughts. Such catastrophic hazards only have a small chance of occurring, but can have devastating results if they do occur.

Natural Hazards can also be divided into ***rapid onset hazards***, such as Volcanic Eruptions, Earthquakes, Flash floods, Landslides, Severe Thunderstorms, Lightening, and wildfires, which develop with little warning and strike rapidly. ***Slow onset hazards***, like drought, insect infestations, and disease epidemics take years to develop.

Anthropogenic Hazards

These are hazards that occur as a result of human interaction with the environment. They include ***Technological Hazards***, which occur due to exposure to hazardous substances, such as radon, mercury, asbestos fibers, and coal dust. They also include other hazards that have formed only through human interaction, such as acid rain, and contamination of the atmosphere or surface waters with harmful substances, as well as the potential for human destruction of the ozone layer and potential global warming.

Effects of Hazards

Hazardous process of all types can have primary, secondary, and tertiary effects.

- *Primary Effects* occur as a result of the process itself. For example water damage during a flood or collapse of buildings during an earthquake, landslide, or hurricane.

- *Secondary Effects* occur only because a primary effect has caused them. For example, fires ignited as a result of earthquakes, disruption of electrical power and water service as a result of an earthquake, flood, or hurricane, or flooding caused by a landslide into a lake or river.

- *Tertiary Effects* are long-term effects that are set off as a result of a primary event. These include things like loss of habitat caused by a flood, permanent changes in the position of river channel caused by flood, crop failure caused by a volcanic eruption etc.

Vulnerability to Hazards and Disasters

Vulnerability refers the way a hazard or disaster will affect human life and property
Vulnerability to a given hazard depends on:

- Proximity to a possible hazardous event
- Population density in the area proximal to the event
- Scientific understanding of the hazard
- Public education and awareness of the hazard
- Existence or non-existence of early-warning systems and lines of communication
- Availability and readiness of emergency infrastructure
- Construction styles and building codes
- Cultural factors that influence public response to warnings

In general, less developed countries are more vulnerable to natural hazards than are industrialized countries because of lack of understanding, education, infrastructure, building codes, etc. Poverty also plays a role - since poverty leads to poor building structure, increased population density, and lack of communication and infrastructure.
Human intervention in natural processes can also increase vulnerability by

- Development and habitation of lands susceptible to hazards, For example, building on floodplains subject to floods, sea cliffs subject to landslides, coastlines subject to hurricanes and floods, or volcanic slopes subject to volcanic eruptions.

- Increasing the severity or frequency of a natural disaster. For example: overgrazing or deforestation leading to more severe erosion (floods, landslides), mining groundwater leading to subsidence, construction of roads on unstable slopes leading to landslides, or even contributing to global warming, leading to more severe storms.

Affluence can also play a role, since affluence often controls where habitation takes place, for example along coastlines, or on volcanic slopes. Affluence also likely contributes to global warming, since it is the affluent societies that burn the most fossil fuels adding CO_2 to the atmosphere.

Assessing Hazards and Risk

Hazard Assessment and Risk Assessment are2 different concepts!

Hazard Assessment consists of determining the following

- when and where hazardous processes have occurred in the past.
- the severity of the physical effects of past hazardous processes (magnitude).
- the frequency of occurrence of hazardous processes.
- the likely effects of a process of a given magnitude if it were to occur now.
- and, making all this information available in a form useful to planners and public officials responsible for making decisions in event of a disaster.

Risk Assessment involves not only the assessment of hazards from a scientific point of view, but also the socio-economic impacts of a hazardous event. Risk is a statement of probability that an event will cause x amount of damage, or a statement of the economic impact in monetary terms that an event will cause. Risk assessment involves

- hazard assessment, as above,
- location of buildings, highways, and other infrastructure in the areas subject to hazards
- potential exposure to the physical effects of a hazardous situation
- the vulnerability of the community when subjected to the physical effects of the event.

Risk assessment aids decision makers and scientists to compare and evaluate potential hazards, set priorities on what kinds of mitigation are possible, and set priorities on where to focus resources and further study.

Prediction and Warning

Risk and vulnerability can sometimes be reduced if there is an adequate means of predicting a hazardous event.

Prediction

Prediction involves:

- A statement of probability that an event will occur based on scientific observation
- Such observation usually involves monitoring of the process in order to identify some kind of ***precursor event(s)*** - an anomalous small physical change that may be known to lead to a more devastating event. - Examples:
    - Hurricanes are known to pass through several stages of development: tropical depression - tropical storm - hurricane. Once a tropical depression is identified, monitoring allows meteorologists to predict how long the development will take and the eventual path of the storm.
    - Volcanic eruptions are usually preceded by a sudden increase in the number of earthquakes immediately below the volcano and changes in the chemical composition of the gases emitted from a volcanic vent. If these are closely monitored, volcanic eruptions can be often be predicted with reasonable accuracy.

Forecasting

Sometimes the word "forecast" is used synonymously with prediction and other times it is not.

- In the prediction of floods, hurricanes, and other weather related phenomena the word forecast refers to short-term prediction in terms of the magnitude, location, date, and time of an event. Most of us are familiar with weather forecasts.
- In the prediction of earthquakes, the word forecast is used in a much less precise way - referring to a long-term probability that is not specific in terms of the exact time that the event will occur. For example: Prior to the October 17 1989 Loma Prieta Earthquake (also know as the World Series Earthquake) the U.S. Geological Survey had forecast a 50% probability that a large earthquake would occur in this area within the next 30 years. Even after the event, the current forecast is for a 63% probability that a major earthquake will occur in this area in the next 30 years.

Early Warning

A warning is a statement that a high probability of a hazardous event will occur, based on a prediction or forecast. If a warning is issued, it should be taken as a statement that "normal routines of life should be altered to deal with the danger imposed by the imminent event".

The effectiveness of a warning depends on:

- The timeliness of the warning

- Effective communications and public information systems to inform the public of the imminent danger.
- The credibility of the sources from which the warning came.

If warnings are issued too late, or if there is no means of disseminating the information, then there will not be time enough or responsiveness to the warning. If warnings are issued irresponsibly without credible data or sources, then they will likely be ignored. Thus, the people responsible for taking action in the event of a potential disaster will not respond.

Frequency of Natural Disasters

Again, it is important to understand that natural disasters result from natural processes that affect humans adversely.

First - Size Matters

For example:

- Humans coexist with rivers all the time and benefit from them as a source of water and transportation. Only when the volume of water in the river becomes greater than the capacity of the stream channel is there a resulting disaster.

- Small earthquakes occur all of the time with no adverse effects. Only large earthquakes cause disasters.

Second – Location, location, location

For example:

- A volcanic on an isolated uninhabited island will not result in a natural disaster.

- A large earthquake in an unpopulated area will not result in a disaster.

- A hurricane that makes landfall on a coast where few people live, will not result in a disaster.

So, what we have to worry about is large events that strike areas where humans live.

Thus, in natural hazards studies, it is important to understand the relationship between frequency of an event and the size of the event. Size is often referred to a ***magnitude***.

For just about any event, statistical analysis will reveal that larger events occur less frequently than small events.

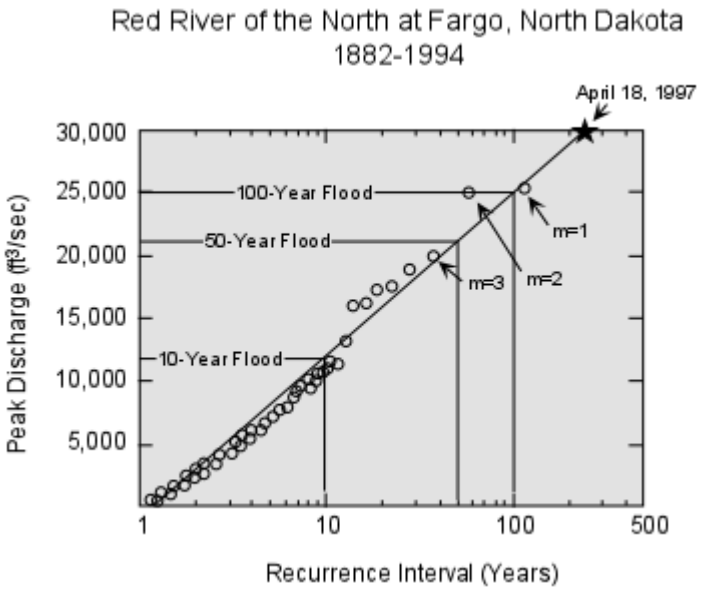
Statistical analysis of some types of events for specific locations allow one to determine the ***return period*** or ***recurrence interval***.

Examples:

Flood Frequency -

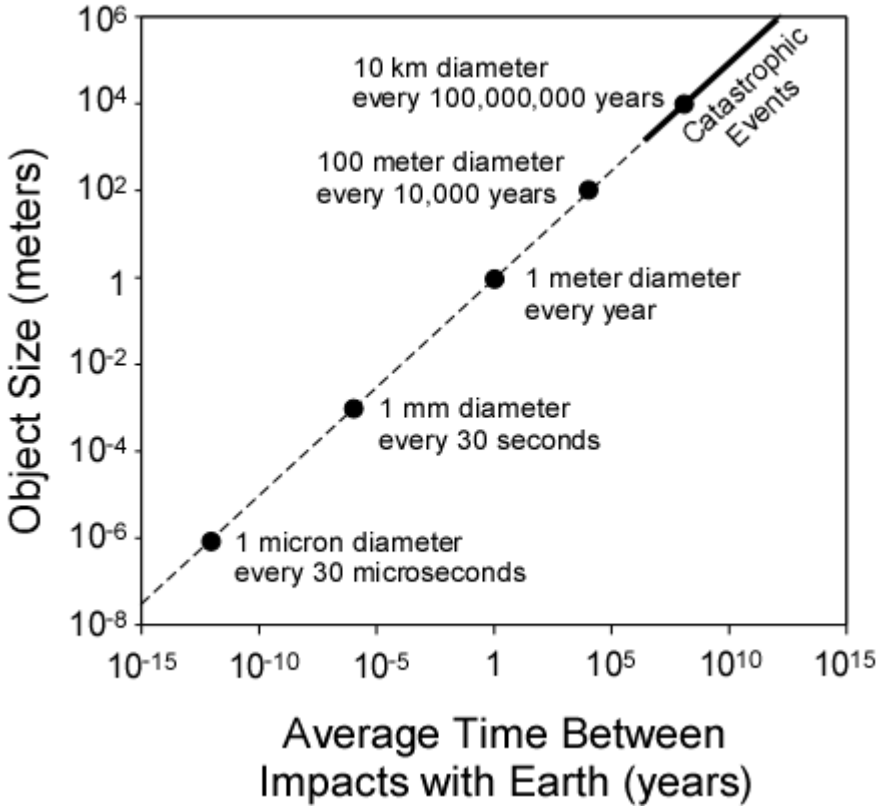
For any river, high discharge events are rare.

Large discharge events occur much less frequently than small discharge events.



Meteorite Impacts -

Although we as humans have not had the opportunity (fortunately) of observing large asteroid or meteorite impacts, the data suggest that impacts of large asteroids (1 km or larger) occurs only once every 10 million years.



Earthquakes -

As we have just noted, large earthquakes occur much less frequently than smaller earthquakes.

Those with magnitudes greater than 8.5 only occur once every 3 years on the average (see Table 3.3 in your text or http://www.iris.edu/hq/gallery/photo/1066)

Is the Frequency of Natural Disasters Increasing?

Are natural disasters becoming more frequent as it seems from news reports of recent activity? The short answer appears to be that yes, natural disasters are increasing in frequency (see http://maps.grida.no/go/graphic/trends-in-natural-disasters. But, this suggests some other important questions before we start making conclusions about the end of the world:

1. Is the frequency of hazardous events increasing?

2. Why is the frequency of natural disasters increasing (what could explain the trend)?

First, Is the frequency of hazardous events increasing? This is much more difficult to answer since natural events responsible for natural disasters have been occurring throughout the 4.5 billion year history of the Earth. Nevertheless, there is no evidence to suggest that hazardous events are occurring more frequently.

What about global warming? There is evidence to suggest that weather related disasters are becoming more frequent, compared to other disasters like earthquakes. For example, the frequency of disasters from tropical cyclones and floods has been increasing, the frequency of earthquakes has changed little. Although this is what we expect from global warming, there is not yet enough statistical data to prove this right now.

Second, is there another explanation for the the frequency of natural disasters increasing? First consider the following facts:

Human population has been increasing at an exponential rate. With more people, vulnerability increases because there are more people to be affected by otherwise natural events.

Human population is moving toward coastal areas (see http://www.livescience.com/4167-flocking-coast-world-population-migrating-danger.html). These are areas most vulnerable to natural hazards such as tropical cyclones, tsunami, and, to some extent, earthquakes.

Our ability to communicate news of natural disasters has been increasing, especially since the invention of the internet. Earlier in human history there may have been just as many disasters, but there were few ways the news of such disasters could be communicated throughout the world.

Meanwhile: Deaths from natural disasters has decreased in developed countries and increased in developing countries. What could explain this? Politics? Economics? Cultural Differences? Education?

The cost of natural disasters has been increasing in developed countries. What could explain this? Economics?

This Course

This course is **not** about the political, cultural, or economic aspects of natural disasters.

It is about the **science of natural disasters** and how can use our knowledge of the scientific aspects of disasters to reduce the death and destruction caused by otherwise natural events.

Textbook Theme

The textbook selected for this course uses 5 fundamental concepts in the study of natural hazards and disasters:

1. Science helps us predict hazards
2. Knowing hazard risk can help people make decisions
3. Linkages exist between natural hazards
4. Humans can turn disastrous events into catastrophes
5. Consequences of hazards can be minimized

We will discuss each of these concepts for each of the hazards we study.

Examples of questions on this material that could be asked on an exam

1. Define and give examples of each of the following types of hazard (a) geologic hazard, (b) atmospheric hazard, (c) catastrophic hazard, (d) rapid onset hazard, (e) anthropogenic hazard (f) slow oneset hazard, .

2. Explain how poverty and affluence can play a role in increasing vulnerability to natural hazards.

3. What is the difference between hazard assessment and risk assessment?

4. What factors determine the effectiveness of warning systems?

5. Explain the difference between primary, secondary, and tertiary effects of possible hazards.

6. What is the relationship between size of natural events, disasters, and frequency of disasters? What is the concept of recurrence interval?

7. What might be responsible for the apparent increase in recent years of the number of natural disasters and the economic losses due to natural disasters?

References
Return to EENS 3050 Homepage