Guide book
Session 1:
Introduction to Disaster Risk Assessment

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Objectives
After this session you should be able to:

- Indicate the causal factors for disasters;
- Evaluate disaster databases and make a profile for your country;
- Find relevant information on disasters on the internet
- Understand the principles of disaster risk reduction;
- Indicate the components that make up a risk assessment
- Understand the main concepts of Risk City;
- Use WebGIS for exploring the data types needed for risk assessment
- Understand the main concepts of ILWIS;
- Use ILWIS for exploring the dataset and evaluating the risk situation in Risk City.

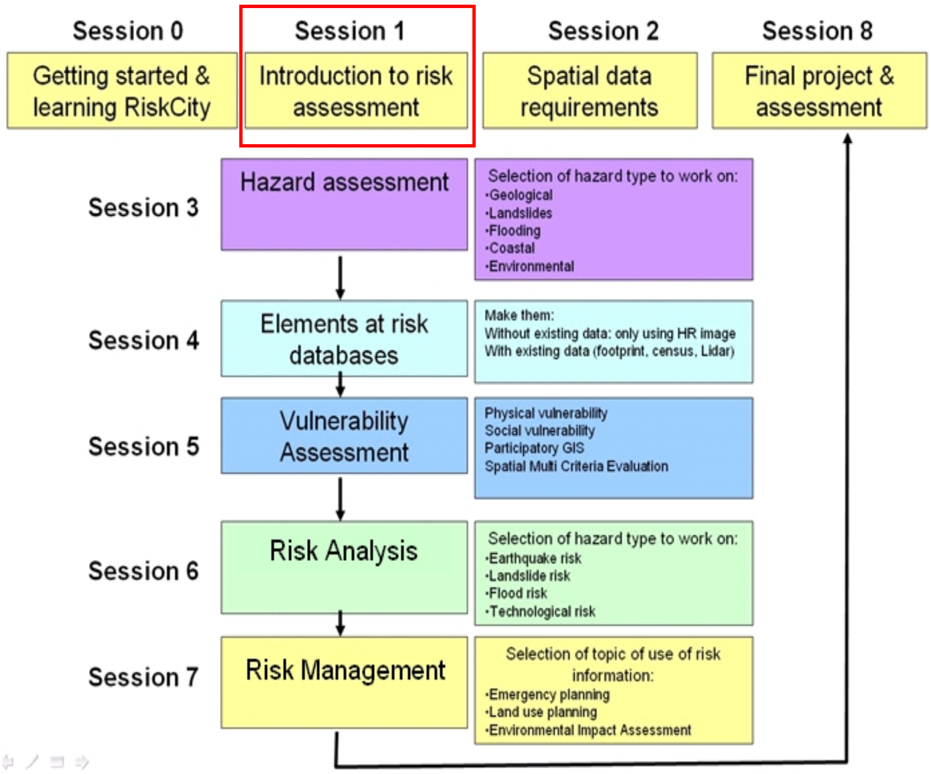
You will do this by using the following materials:

- The first part of the guidance notes deals with an introduction to disasters, disaster statistics, disaster management and risk assessment.
- The second part of the guidance notes deals with a brief introduction to the tools: WebGIS and the ILWIS software.
- RiskCity exercise 1: Introducing ILWIS and the dataset.
- Assignments: at the end of this session you are requested to carry out the following assignments and evaluations.
- As an overall task you are asked to make a disaster profile of a particular country (preferably you own country) in which you describe the main hazard types, areal extend, and losses due to disasters, using the various resources that will be treated in this chapter.

This table below gives an indication of the sections, tasks and the required time.

Section	Topic	Task	Time required		
1.1	Introduction to disasters		Day 1	1 h	2.8 h
		Task 1.1: Recent disaster		0.1 h	
		Task 1.2: what is a disaster		0.1 h	
		Task 1.3: Natural disaster?		0.1 h	
		Task 1.4: Nathan internet search		0.25 h	
		Task 1.5: Disaster databases		1.00 h	
		Task 1.6: Real time information		0.25 h	
		Tasks 1.7: Disaster profile		1.00 h	
1.2	Disaster Risk Management			0.5 h	0.65
		Task 1.8: video		0.15 h	
1.3	Risk Assessment		Day 2	0.5 h	0.65
		Task 1.9: Exposure		0.15 h	
1.4	RiskCity case study			0.5 h	0.5
1.5	The Tools: WebGIS and GIS			0.5 h	3.5 or 1.5
		Task 1.10: WebGIS exercise (optional)		1 h	
		Task 1.11: RiskCity exercise 1: Introduction to ILWIS and RiskCity		3 h	
				Total	**8.1 h**

1.1 Introduction to disasters



This chapter is the first of a total of 8 chapters that will guide you through the process of spatial multi-hazard risk assessment. This chapter will introduce the concepts of disasters, the types of disasters, their causes and statistics. After that a section deals with disaster risk management, before going to the concept of risk. An introduction is given of risk and risk assessment. The last part of the chapter has a description of the case study RiskCity and the OpenSource ILWIS software.

1.1.1 What are disasters?

Disasters appear on the headlines of the news almost every day. Most happen in far- away places, and are rapidly forgotten by the media. Others keep the attention of the world media for a large period of time. The events that receive maximum media attention are those that hit instantaneously and cause widespread losses and human suffering, such as earthquakes, floods and hurricanes. Recent examples are the Indian Ocean tsunami (2004), the earthquakes in Pakistan (2005), Indonesia (2006) and China (2008) and the hurricanes in the Caribbean and the USA (2005, 2008). On the other hand there are very serious slow onset geomorphologic hazards, such as soil erosion, land degradation, desertification, glacial retreat in mountains etc. that may cause much larger impacts on the long run but receive less media attention.

Task 1.1: Internet assignment (duration 10 minutes)
Know any recent disaster ?
Go to the internet page of your favorite newspaper or press agency and check for items related to disasters for the past few days. Alternatively if you don't have good internet access you may also consult your local newspaper for that.
Which events are reported ?

There are many ways in which you could define disasters:

Definitions of disaster:

- A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources.

(Source: http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm)

- An extreme event within the earth's system (lithosphere, hydrosphere, biosphere or atmosphere) which differs substantially from the mean, resulting in death or injury to humans, and damage or loss of 'goods', such as buildings, communication systems, agricultural land, forest, and natural environment (Alexander, 1993)
- A disaster occurs when a significant number of vulnerable people experience a hazard and suffer severe damage and/or disruption of their livelihood system in such a way that recovery is unlikely without external aid. (Blaikie 1994)

When considering all definitions we can 'characterize' a disaster as:

- an extreme phenomenon (of different origins),
- of large intensity (e.g. a measurable quantity such as earthquake intensity, water depth)
- and limited duration (which can vary from seconds to months, but should be defined in time);
- occurring at a certain location (this spatial component will be very important in this course);
- involving a complex interplay between physical and human systems;
- causing loss of lives and threats to public health, as well as physical damage
- and disruption of livelihood systems and society;
- exceeding local capacities and resources;
- requiring outside assistance to cope with.

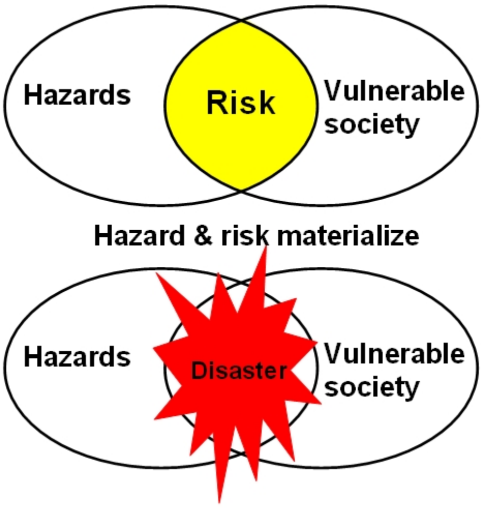


Figure 1.1: A disaster occurs when the threat of a hazard become reality, and impacts on a vulnerable society.

Task 1.2: Question (duration 5 minutes)
What is a disaster ?

To illustrate the above mentioned aspects, consider for yourself whether you would indicate the following situations a 'disaster':

1. *When you become ill, and cannot work anymore?*
2. *When a famous football player is injured and misses the most important match, and his team loses the word championship?*
3. *When does a car accident become a disaster? The annual financial cost of car accidents in the US is estimated to be around 230 Billion dollars, with 2.9 million injuries and around 43,000 casualties.*
4. *The death of 2,974 people in the attack on the Twin Towers on 9/11/2001?*
5. *The financial crises that hit the world in 2008?*
6. *Is HIV/AIDS a disaster?*

You can comment on these situations on the discussion forum in Blackboard. You can also come up with other examples that illustrate that the definition of 'disaster' is not a very straightforward one and can also been seen at the level (e.g. of an individual, family community, society)

It is important to distinguish between the terms *disaster* and *hazard*. A disaster is a function of the risk process. Risk results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk.

Hazards can include latent conditions that may represent future threats. When the threat becomes a reality, or when it materializes, the risk becomes a disaster. For example, a certain area might be located in a region where earthquakes might occur. There is a certain hazard. There is only risk if within the earthquake hazard area there is a vulnerable society. There is a risk that a future earthquake might cause considerable casualties and losses. When the hazard materializes, the earthquake actually takes place, causing the losses and casualties to the vulnerable society, and creating the disaster. An event such as an earthquake by itself is not considered a disaster when it occurs in uninhabited areas. It is called a disaster when it occurs in a populated area, and brings damage, loss or destruction to the socio-economic system.

Definitions of hazard :

- A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

  (Source: http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm)
- The probability of occurrence within a specified period of time and within a given area of a potentially damaging phenomenon" (UNDRO, 1991).

1.1.2 Disaster types

A hazard, and the disaster resulting from that, can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterised by its location, intensity, frequency, probability, duration, area of extent, speed of onset, spatial dispersion and temporal spacing. We will look at this much more in later sessions. Hazards can be classified in several ways. A possible subdivision is between:

- *Natural hazards* are natural processes or phenomena within the earth's system (lithosphere, hydrosphere, biosphere or atmosphere) that may constitute a damaging event (such as earthquakes, volcanic eruptions, hurricanes);
- *Human-induced hazards* are modifications and of natural processes within the earth's system (lithosphere, hydrosphere, biosphere or atmosphere) caused by human activities which accelerate/aggravate damaging events (such as atmospheric pollution, industrial chemical accidents, major armed conflicts, nuclear accidents, oil spills);
- *Human-made hazards or technological hazards*: dangers originating from technological or industrial accidents, dangerous procedures, infrastructure failures or certain human activities, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation (Some examples: industrial pollution, nuclear activities and radioactivity, toxic wastes, dam failures; transport, industrial or technological accidents (explosions, fires, spills).

A natural hazard may cause a disaster to a vulnerable society. However, one should be careful not to refer to these as 'natural disasters' as in disaster risk literature a lot of emphasis is place on the fact that disasters are relationships between hazards and vulnerable societies (O'Keefe, Westgate & Wisner, 1976). On the other hand, many use the terms 'natural disasters', 'human-induced disasters' and 'technological disasters' to indicate the origin of the cause of the extreme event.

Task 1.3: Question (duration 5 minute)

There are situations where one could speak about 'natural disasters' when the impact of the disaster is on the natural environment.
Can you give an example of that?

In the following pages you can find several examples of recent disasters with links to Youtube videos and a general description.

Example technological disasters: the 2000 Enschede fireworks explosion

Watch the You Tube video's such as:
http://uk.youtube.com/watch?v=MVqCWErj2Pc (overview, better turn sound off)
http://uk.youtube.com/watch?v=Ks5X0N8M_o8 (this is the shooting of the actual disaster how it unfolds). If you don't have a good internet connection you can also watch the video: **Enschede_Firework_disaster** which is on the course DVD.

The disaster happened on 13 May 2000 in Enschede, the Netherlands, at 300 meters from the location of the ITC building. The explosion took place in a company that makes fireworks during large events, such as rock concerts. On its premises it contained a bunker for fireworks, which was overloaded at the time. Also 23 large sea-containers with heavy fireworks were on the premises. The local government had given permission for the expansion and had not paid sufficient attention to provide licenses. The national organization for the checking of firework storage sites was also not operation very well. The firework storage area was in a location officially indicated for industrial purposes on the land regulation plan. However, on the other side of the street was a residential area. The local fire-brigade had no idea about the danger of the site, and had no prior knowledge of the firework amounts stored there. On 13 May the events started with a small fire (the origin of this was never discovered). The fire-brigade was extinguishing the fire with 3 fire trucks. Many people were watching as there was a constant display of firework. Suddenly the fire grew larger, and resulted in two major explosion. The second one detonated all firework containers and bunkers and caused a firestorm over the entire neighborhood, setting fire to many residential and industrial buildings.

Size of the disaster area	**40 ha**
Number of inhabitants in most affected zone	**4163**
Number of completely destroyed houses	**205**
Number of completely damaged business and industrial buildings	**± 50**
Number of houses declared "inhabitable"	**293**
Number of damaged houses outside mostly affected zone	**ca. 1500**
Number of persons killed	**22**
Number of persons injured	**947**
Number of homeless persons	**1250**
Number of persons that had to be evacuated	**± 10.000**
Total material damage	**0.5 billion Euro**

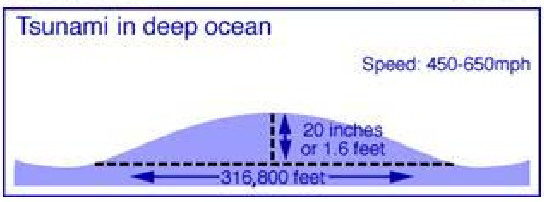

The image above shows the situation after the explosion. Almost an area of 1 square kilometer was devastated by the explosion. In fact all buildings visible on this image had to be demolished. In the top part you can see the large white building of the Grolsch Brewery. This building had a number of large ammonium tanks in the front part, which nearly caught fire. After the event the rules for firework storage changed dramatically, as well as the rules for building regulations which now also take into account the distance towards hazardous installations.

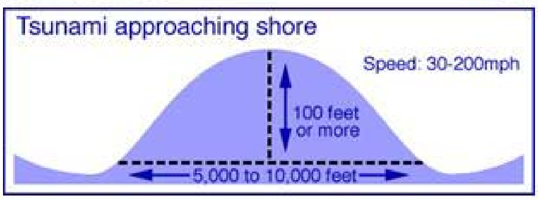
Also a Web-GIS with a risk map for the entire Netherlands was generated as a consequence of this disaster. See: www.risicokaart.nl (this will further treated in session 7)

Example Geological disasters: the 2004 tsunami
There are many examples of videos that depict this large tragedy on Youtube, for example:
http://uk.youtube.com/watch?v=R-jlyfzGP-o&NR=1
http://uk.youtube.com/watch?v=FCWfRs1frYE&feature=related
http://www.youtube.com/watch?v=FAtn4KSwxVQ
If you don't have internet access, you can also watch the video: **Tsunami_2004** on the DVD of the course.

The Indian Ocean tsunami occurred on December 26 2004. It was caused by an earthquake with a Magnitude of 9.3, occurring approximately 160 km north of Simeulue island, off the western coast of northern Sumatra, at a depth of 30 km. An estimated 1,600 km of faultline slipped about 15 m along the subduction zone where the India Plate slides under the Burma Plate. The tsunami which resulted from this hit the coasts of all countries surrounding the Indian Ocean, with main devastation in Indonesia, Sri Lanka, Malidives, India and Thailand.

Country where deaths occurred	Deaths		Injured	Missing	Displaced
	Confirmed	Estimated[1]			
Indonesia	130,736	167,736	—	37,063	500,000+
Sri Lanka[2]	35,322	21,411			516,150
India	12,405	18,045	—	5,640	647,599
Thailand	5,395[3]	8,212	8,457	2,817	7,000
Somalia	78	289	—	—	5,000
Myanmar (Burma)	61	400–600	45	200	3,200
Maldives	82	108	—	26	15,000+
Malaysia	68	75	299	6	—
Tanzania	10	13	—	—	—
Seychelles	3	3	57	—	200
Bangladesh	2	2	—	—	—
South Africa	2[4]	2	—	—	—
Yemen	2	2	—	—	—
Kenya	1	1	2	—	—
Madagascar	—	—	—	—	1,000+
Total	~184,168	~230,210	~125,000	~45,752	~1.69 million





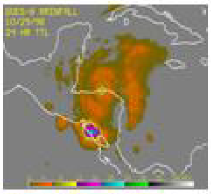
Example Hydro-meteorological disasters: Hurricane Mitch hitting Honduras

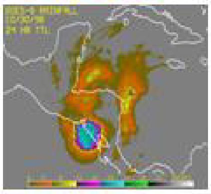
There are several videos on YouTube that give a good introduction to this event, e.g. http://uk.youtube.com/watch?v=0A4ufJ66TUs **(9 minutes focusing on the disaster in Tegucigalpa , the capital of Honduras)**

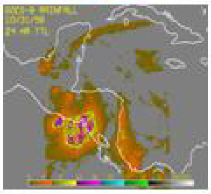
If you don't have internet access, you can also watch the video: **Honduras_Mitch** on the DVD of the course

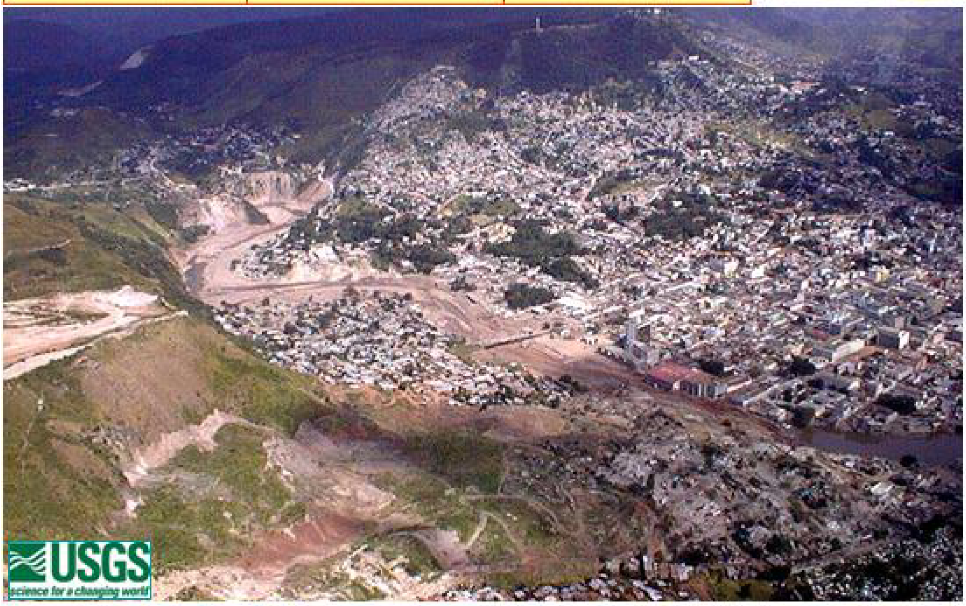
Mitch was one of the most catastrophic events in recent history in the Central American region. It hit several countries, but Honduras was one of the most affected with with over 7000 killed, 8000 missing and 12000 injured. Over 2 million people were evacuated. The capital of Honduras, Tegucigalpa suffered severe damage from landslides and flooding during Hurricane Mitch in October 1998 when the city received 281 mm of rain in 3 days. Due to river flooding, an old landslide was reactivated and an entire neighborhood on top of it was destroyed. The landslide caused the damming of the river and resulted in severe flooding in large parts of the city center for several weeks. The RiskCity case study is based on this example (See session 1.4)

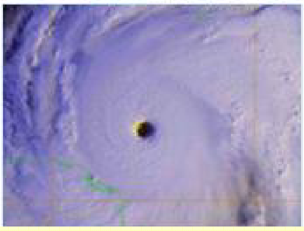
Region	Direct deaths	Damage
Panama	3	Unknown
Costa Rica	7	$92 million
Jamaica	3	Unknown
Nicaragua	3,800	$1 billion
Honduras	7,000	$3.8 billion
Guatemala	268	$748 million
El Salvador	240	$400 million
Belize	11	Unknown
Mexico	9	Unknown
United States	2	$40 million
Offshore	31	*N/A*
Total	**~11,374**	**$6 billion**

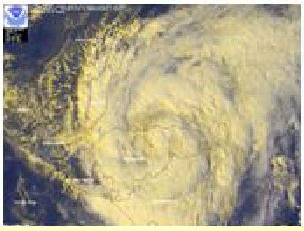












Another subdivision relates to the main controlling factors leading to a disaster. These may be meteorological (too much or too little rainfall, high wind-speed), geomorphological/geological (resulting from anomalies in the earth's surface or subsurface), ecological (regarding flora and fauna), technological (human made), global environmental (affecting the environment on global scale) and extra terrestrial (See table 1.1).

Meteorological	**Geomor-phological & Geological**	**Ecological**	**Technological**	**Global environmental**	**Extra terrestrial**
Drought Dust storm Flood Lightning Windstorm Thunderstorm Hailstorm Tornado Cyclone Hurricane Heat wave Cold wave	Earthquake Tsunami Volcanic eruption Landslide Snow avalanche Glacial lake outburst Subsidence Coal fires Coastal erosion	Crop disease Animal disease Insect infestation Forest fire Mangrove decline Coral reef decline Pesticides	Armed conflict Land mines Major (air-, sea-, land-) Traffic accidents Nuclear / chemical accidents Oil spill Water / soil / air pollution Electrical power breakdown	Acid rain Atmospheric pollution Global warming Sealevel rise El Niño Ozone depletion	Asteroid impact Aurora borealis

Table 1.1: Classification of disasters according to the main controlling factor.

In literature sources several other classifications of disasters can be found, for instance by putting emphasis on the degree to which the origin of the disaster (the hazard event) is purely natural, human-induced or man-made. In this classification there will be several disaster types that are in different categories. Landslides, for instance, can be purely natural phenomena, but are also often human-induced. Other examples of events that can be both natural as well as human-induced are flooding, forest fires and snow avalanches. But also extreme meteorological events that may have an increased severity and frequency due to global warming, caused by human-induced CO2 emissions. The UN-ISDR (see also 1.2) uses another classification of disasters (http://www.unisdr.org/disaster-statistics/introduction.htm):

- Hydro-meteorological disasters: including floods and wave surges, storms, droughts and related disasters (extreme temperatures and forest/scrub fires), and landslides & avalanches;
- Geophysical disasters: divided into earthquakes & tsunamis and volcanic eruptions;
- Biological disasters: covering epidemics and insect infestations

1.1.3 Disaster location

Natural disasters occur in many parts of the world, although each type of disaster is restricted to certain regions. Figure 1.2 gives an indication of the geographical distribution of a number of major hazards, such as earthquakes, volcanoes, tropical storms and cyclones. It is clear from this figure that certain hazard occur in particular regions, such as:

- Earthquakes occur along active tectonic plate margins, and volcanos occur along subduction zones (e.g. around the margins of the Pacific plate, so-called 'Ring of Fire')
- Tsunamis occur in the neighborhood of active plate margins, but also at a considerable distance from these as tsunami waves can travel over large distances.
- Tropical cyclones (in North America called 'hurricanes' and in Asia called 'typhoons') occur in particular zones indicated with green areas in the map. Landslides occur in hilly and mountainous regions.

Task 1.4: Internet assignment (15 minutes)
NATHAN interactive search
Visit the website of NATHAN (Natural Hazard Analysis Network) of the Munich Re Insurance Company: http://mrnathan.munichre.com/
Use the Web-GIS application to view the hazard situation of your own country, and view the country profile

Münchener Rück
Munich Re Group
NATURAL HAZARD MAPS

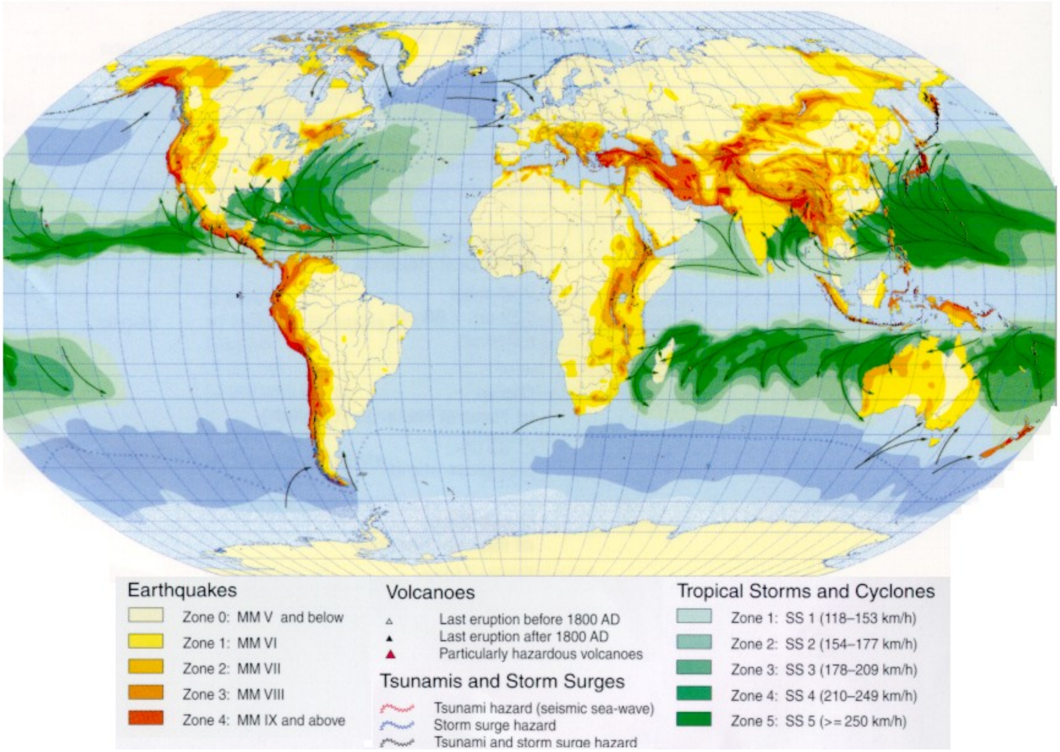


Figure 1.2: World map of natural hazards (Source: www.MunichRe.com)

The map below also gives an indication of the relative occurrence of main hazard types per continent.

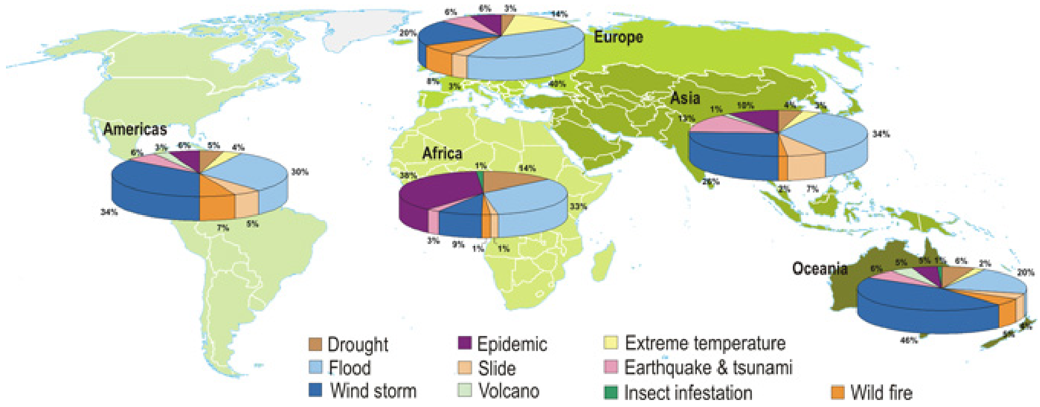


Figure 1.3 Relative importance of main hazard types per continent (source: www.unisdr.org/disaster-statistics/introduction.htm and www.emdat.be)

Recently a project on the "Identification of Global Natural Disaster Risk Hotspots" was carried out under the umbrella of the ProVention Consortium by World Bank staff from the HMU and the Development Economics Research Group (DECRG) and Columbia University. See also session 6.4.2.

1.1.4 Disaster statistics

Data on disaster occurrence, its effect upon people and its cost to countries are very important for disaster risk management. There are now a number of organizations that collect information on disasters, at different scales and with different objectives.

- Since 1988 the WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED) has been maintaining an Emergency Events Database - EM-DAT (www.em-dat.be). Disasters have to fulfill certain criteria in order to be included in the EMDAT database: they have to kill 10 people or more, 100 or more should be affected, it should result in a declaration of emergency or it should lead to a call for external assistance.

- Data on disaster impacts are also collected by reinsurance companies. (www.MunichRe.com; www.swissre.com). For instance the Munich Re data base for natural catastrophes NatCatSERVICE includes more than 23,000 entries on material and human loss events worldwide. However, these data are not publicly available. There is only a very general site where disaster information can be obtained: http://mrnathan.munichre.com/
- Recently the Asian Disaster Reduction Center (ADRC) has started a new disaster database, called Glidenumber. See www.glidenumber.net The database however is still very incomplete.
- Another useful source of disaster information for individual countries is the UNDP website: http://gridca.grid.unep.ch/undp/ Here you can also compare the disaster situation of two selected countries.
- At a local level disaster data has been collected by an initiative of NGO, called LaRed, initially in Latin America, but later on expanding also to other regions. They generated a tool called DesInventar, which allows local authorities, communities and NGO's to collect disaster information at a local level. Recently the DesInventar database has become available online: http://online.desinventar.org

Task 1.5: Internet assignment (duration 1 hour)
Evaluating disaster databases
The aim of this assignment is to evaluate the completeness of the disaster databases. Select either to search disasters for your own country or select some well known disaster events in other countries that you know about.

- *Start with making a query using the EMDAT database, via www.emdat.be You can either use the Advanced Search. Check also the Trends section to get an idea of the overall trends in hazards and disaster, which we will also discuss below. If you don't have a (good) internet connection you can also analyse the database in Excel format, entitled:* ***EMDAT_database***.
- *Compare this with the data from Glidenumber, via: www.glidenumber.net for the same country or disaster.*
- *Finally go to the site http://online.desinventar.org and see if there are data available for your country or the disaster you have selected.*
- *Perhaps you know also local disaster databases for your own country. Google for them, and if you have found them, also report them.*

What can you conclude on the completeness of the disaster databases?

When we look at the number of reported disasters in the EMDAT database, there is a clear increase in hazardous events over the last decades. When we look at the data in the table below it is clear that this cannot be explained only by the better reporting methods for disasters, which probably made the number too low for the first part of the last century. The large increase is particularly for hydrometeorological events.

	1900 1909	1910 1919	1920 1929	1930 1939	1940 1949	1950 1959	1960 1969	1970 1979	1980 1989	1990 1999	2000 2005	Total
Hydrometeorological	28	72	56	72	120	232	463	776	1498	2034	2135	7486
Geological	40	28	33	37	52	60	88	124	232	325	233	1252
Biological	5	7	10	3	4	2	37	64	170	361	420	1083
total	73	107	99	112	176	294	588	964	1900	2720	2788	9821

Table 1.2: Statistics of great natural disasters for the last four decades (source: www.unisdr.org/disaster-statistics/introduction.htm and www.emdat.be)

This is confirmed by the databases of the reinsurance companies, although the figures are only reported for 'great' disasters. As a rule, this is the case when there are thousands of fatalities, when hundreds of thousands of people are left homeless. See figure 1.4.
The impact of natural disasters to the global environment is becoming more severe over time, as can be seen from table 1.3.
Earthquakes result in the largest amount of losses. Of the total losses it accounts for 35%, ahead of floods (30%), windstorms (28%) and others (7%). Earthquake is also the main cause in terms of the number of fatalities, which is estimated in the order of 1.4 million during the period 1950-2000 (47%), followed by windstorms (45%), floods (7%), and others (1%) (Sources: Munich Re., and EMDAT).

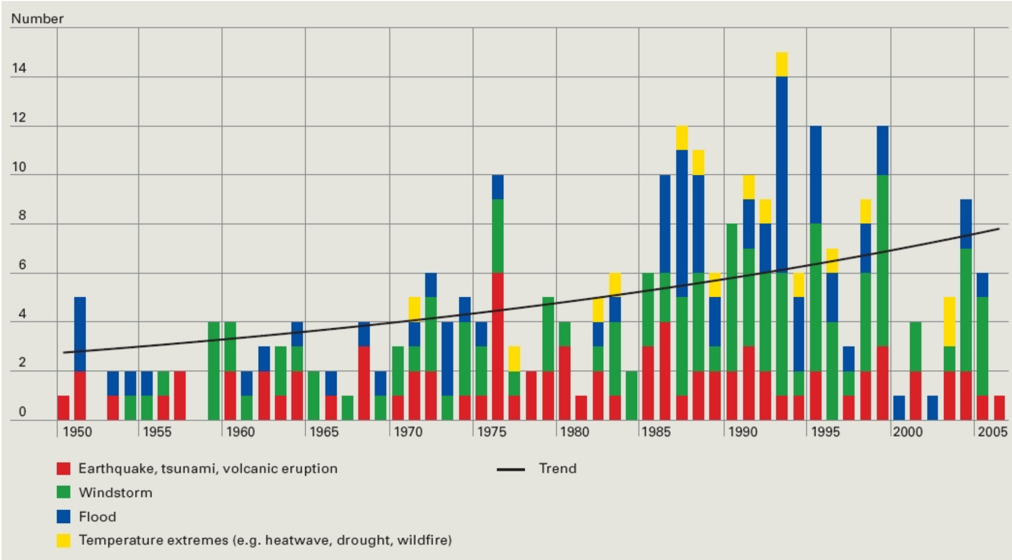


Figure 1.4: Number of 'great' natural disasters since 1950 (source: www.munichre.com)

	Decade 1960 - 1969 US $ billion	Decade 1970 -1979 US $ billion	Decade 1980 - 1989 US $ billion	Decade 1990 - 2000 US $ billion	Factor 90s: 60s
Number of large disasters	27	47	63	82	3.0
Economic losses	69.0	124.2	192.9	535.9	7.8
Insured losses	6.6	11.3	23.9	98.8	15.0

Table 1.2: Statistics of great natural disasters for the last four decades (source: www.MunichRe.com)

There are several problems in using the data from the EMDAT database. These are summarized by UNISDR and CRED as follows:

"Today key problems with disaster data remain the lack of standardised collection methodologies and definitions. The original information, collected from a variety of public sources, is not specifically gathered for statistical purposes. Even when the compilation is based on strict definitions for disaster events and parameters, the original suppliers of information may not follow rigorous criteria. Moreover, data are not always complete for each disaster. The degree of completion may vary according to the type of disaster or its country of occurrence.

- *Data on deaths are most of the time available because there is an immediate proxy for the severity of the disaster. However, the numbers put forward in the first few moments after a disaster may be significantly revised, even several months later.*
- *Data on the numbers of people affected by a disaster can be very useful for risk assessment, but are often poorly reported. Moreover, the definition of "affected" remains always open to interpretation, political or otherwise. Even in absence of manipulation data can be extrapolated from old census information, with assumptions being made about the percentage of an area's population affected.*
- *Data can also be skewed because of the rationale behind data gathering. Reinsurance companies, for instance, systematically gather data on disaster occurrence in order to assess insurance risk, but with a priority in areas of the world where disaster insurance is widespread. Their data may therefore miss out poor disaster-affected regions where insurance is unaffordable or unavailable.*
- *For natural disasters during the last decade, data on deaths are missing in about 10 per cent of the disasters; around 20 per cent lack information on the total number of people affected, and about 70 per cent do not cover economic damages. The figures therefore should be regarded as indicative. Relative changes and trends are more useful to look at than absolute, isolated figures.*
- *Dates can also be a source of ambiguity. For example, a declared date for a drought is both necessary and meaningless - drought does not occur in a single day. In such cases, the date the appropriate body declares an official emergency has been used.*
- *Changes in national boundaries also cause ambiguities in the data and may make long-term trends analysis more complicated.*

Information systems have improved vastly in the last 25 years and statistical data is now more easily available, intensified by an increasing sensitivity to disasters occurrence and consequences. However, despite efforts to verify and review data, the quality of disaster databases can only be as good as the reporting system. The lack of systematisation and standardisation of data collection reveals now its major weakness for long-term planning. Fortunately, due to increased pressures for accountability from various sources, many donors and development agencies have increased their attention on data collection and its methodologies" (source: http://www.unisdr.org/disaster-statistics/introduction.htm).

The strong increase in losses and people affected by natural disasters is partly due to the developments in communications, as hardly any disaster passes unnoticed by the mass media.

Task 1.6: Internet assignment (duration 15 minutes)
Getting real-time information on disasters
There are also many websites where you can get information about disasters that are happening now. Some of the most important ones are:

- ***ReliefWeb** is the world's leading on-line gateway to information (documents and maps) on humanitarian emergencies and disasters. ReliefWeb was launched in October 1996 and is administered by the UN Office for the Coordination of Humanitarian Affairs (OCHA). http://www.reliefweb.int/*
- *The Website of **AlertNet/Reuters**: www.alernet.org Here it might be also good to check out their maps section, as well as the Interactive map search using Microsoft Virtual Earth.*
- ***HEWSWEB** is a joint effort of several organization lead by the World Food Programme (WFP). The IASC Humanitarian Early Warning Service (HEWSweb) is an inter-agency partnership project aimed at establishing a common platform for humanitarian early warnings and forecasts for natural hazards. The main objective of HEWSweb is to bring together and make accessible in a simple manner the most credible early warning information available at the global level from multiple specialized institutions. Their website is particularly good in providing map information on hazard events: http://www.hewsweb.org/*

There are a number of factors responsible for the large increase in the number of disasters, which can be subdived in factors leading to a larger vulnerability and factors leading to a higher occurrence of hazardous events.
The **increased vulnerability** is due to:

- The rapid increase of the world population, which has doubled in size from 3 billion in the 1960s to 6 billion in 2000. Depending on the expected growth rates, world population is estimated to be between 7 and 10 billion by the year 2050 (*http://esa.un.org/unpp/*).
- However, the increase is disaster impact is higher than the increase in population, which indicates that there are other important factors involved that increase the overall world population.

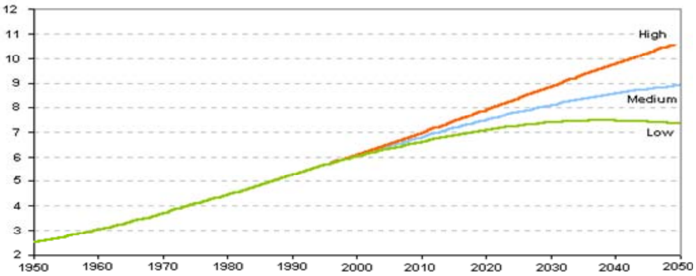


Figure 1.5: Population estimates according the UN. Source: http://esa.un.org/unpp/

- One of the main aspects is the large urbanization rate. According to UN figures (*http://esa.un.org/unpp/*) the worldwide urbanization percentage has increased from 29 to 50 % now and is expected to rise to 70 in 2050. Another factor related to the population pressure is that areas become settled that were previously avoided due to their susceptibility to natural hazards.
- Many of the largest cities in the world, the so-called 'Megacities' are located in hazardous regions, either in coastal zones, or in seismically active regions (see: http://www.megacities.uni-koeln.de/index.htm)
- The increasing impact of natural disasters is also related with the development of highly sensitive technologies and the growing susceptibility of modern industrial societies to

breakdowns in their infrastructure. Table 1.2 shows the distribution of economic and insured losses due to natural disasters during the last 4 decades.

- There is a rapid increase in the insured losses, which are mainly related to losses occurring in developed countries. Windstorms clearly dominate the category of insured losses (US $90 billion), followed by earthquakes (US $ 25 billion). Insured losses to flooding are remarkably less (US $ 10 billion), due to the fact that they are most sever in developing countries with lower insurance coverage (www.munichre.com).

However, it is not only the increased exposure of the population to hazards that can explain the increase in natural disasters. The **frequency of destructive events** related to atmospheric extremes (such as floods, drought, cyclones, and landslides) is also increasing. During the last 10 years a total of 3,750 windstorms and floods were recorded, accounting for two-thirds of all events. The number of catastrophes due to earthquakes and volcanic activity (about 100 per year) has remained constant. Although the time-span is still not long enough to indicate it with certainty, these data indicate that climate change is negatively related with the occurrence of natural disasters. There will be more on the relation between climate change and disasters in chapter 3.

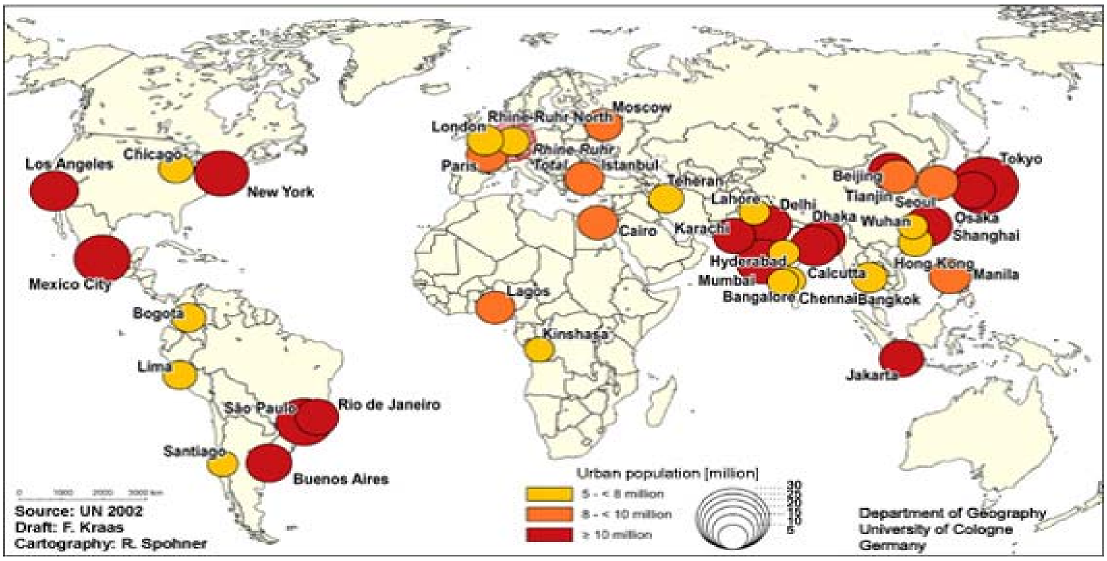


Figure 1.6: Megacities. Source: http://www.megacities.uni-koeln.de/index.htm)

1.1.5 Disasters and development

There is an inverse relationship between the level of development and loss of human lives in the case of a disaster. About 95 percent of the disaster related casualties occur in less developed countries, where more than 4.200 million people live. The greater loss of lives due to disasters in developing countries is due to several reasons:

- The buildings are often of lesser quality, due to lack of building codes or lack of enforcement of them, if they do exist. Therefore they have a higher chance of collapse, during a hazardous event.
- More buildings are constructed in hazardous areas due to lack of land use planning
- Lower awareness and disaster preparedness
- Less accurate or missing early warning systems
- Less accurate of missing evacuation planning
- Less adequate search-and-rescues and medical facilities after a disaster.

Disasters strike everywhere, in developing and developed countries (see figure 1.8). However, the effect of disasters on the economy is relatively much larger in developing countries.
Economic losses due to natural disaster can be very high in absolute terms, especially in developed countries. In the period 1991 – 2005 for instance, the USA had an estimated loss of 365 Billion US$, Japan 209, and China 173. However, economic losses attributable to natural hazards in less developed countries may represent as much as 100 % of their Gross Domestic Product. GDP is the total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of

exports, minus the value of imports. See for instance the list of 50 events that caused the highest losses in terms of GDP on http://www.unisdr.org/disaster-statistics/top50.htm
Figure 1.9 gives a general indication of the relationship between the level of development and disaster losses. Economic losses in absolute terms (billions of dollars) are shown as a red line. They show an increase with the level of development, as the absolute value of elements at risk that might be damaged during a disaster increases with increasing level of development. However, in relative terms (percentage of GDP) the trend is reverse, as indicated by the dotted red line.

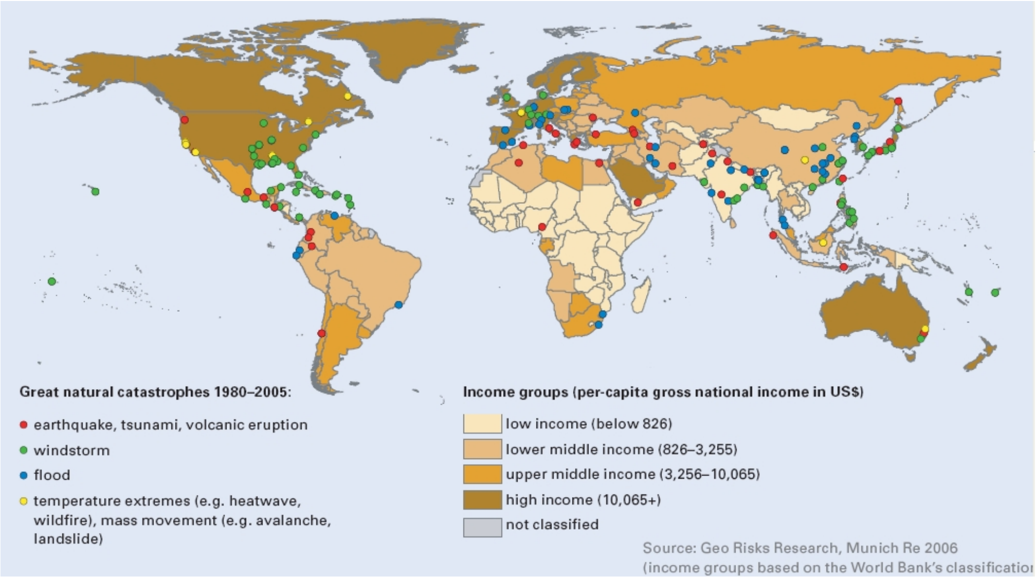


Figure 1.8: Overlay of great natural disasters and income (Source: www.MunichRe.com)

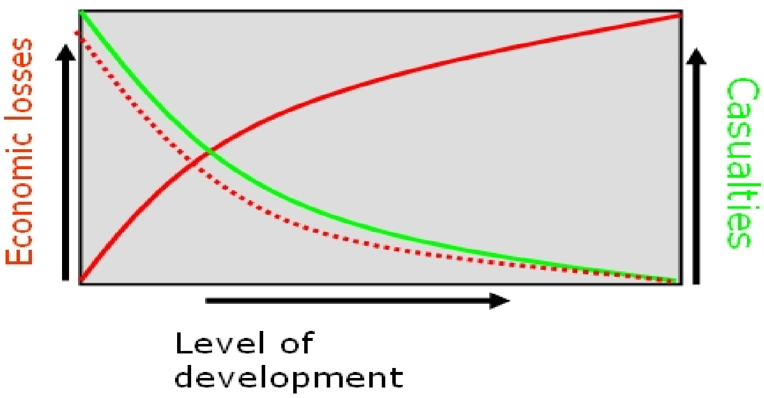


Figure 1.9: The figure indicates the relation between level of development, casualties and economic losses. When economic losses are indicated as percentage of GDP (dotted red line) the relation is opposite compared to the absolute economic losses.

Task 1.7: Making a disaster profile of a country (1 hour)

After the introductory session on disasters, we would like you to ultilize the information that was presented thus far in order to make a profile of your own country with respect to disasters. The aim of this assignment is to make a disaster profile of a particular country (preferably you own country) in which you describe the main hazard types, areal extend, and losses due to disasters, using the various resources that will be treated in this chapter.
Use internet resources, such as the ones indicated in this chapter to search for disaster statistics, hazard occurrences, and the effect disasters have on the economy.

Make a small report of maximum 5 pages which you submit through Blackboard or through e-mail to the course coordinator.

1.2 Disaster Risk Management

1.2.1 Introduction

The general framework of this book is based on the Disaster Risk Management (DRM) approach promoted by the United Nations through the International Strategy for Disaster Reduction – ISDR. One of the key premises in this approach is that disasters are not seen as events of nature by itself but the product of intricate relationships linking the natural and organizational structure of a society (UN-ISDR, 2005). Given the strength of the physical forces involved and the human socioeconomic interdependence on climate and the environment, it is unlikely that adverse impacts from climate events will ever be totally eliminated. Still, efforts to understand and dig in the root causes of disasters clearly indicate that there is considerable scope, both at a macro and household level, to handle the extent and nature of disaster occurrence.

Disasters could, in fact, be reduced, if not prevented, their impact on peoples and communities' mitigated, and human action or inaction to high risk and vulnerability to natural hazards could spell the difference (Birkmann, 2006). Human societies have, therefore, the responsibility to identify the risks and factors leading to disasters and decide on the appropriate interventions to control or manage them.

Risk assessment is then a central stage that, more than a purely scientific enterprise should be seen as a collaborative activity that brings together professionals, authorized disaster managers, local authorities and the people living in the exposed areas.

Disaster Risk Reduction (DRR) refers to the conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development

Disaster Risk Management (DRM) can be described as an array of measures involving public administration, decentralization, organizational and institutional development (or strengthening), community-based strategies, engineering, settlement development and land use planning. It also takes into consideration environmental issues as part of the risk mitigation and reduction strategies

1.2.2 Shift in paradigm

One way of dealing with natural disaster events is to ignore their threats. Until recently in many parts of the world, neither the population nor the authorities choose to take the danger of natural hazards seriously. The complacency may be due to the last major destructive event having happened in the distant past, or people may have moved in the area recently, without having knowledge about potential hazards. Alternatively, the risk due to natural hazards is often taken for granted, given the many dangers and problems confronted by people. Authorities sometimes may ignore hazards, because the media exposure and ensuing donor assistance after a disaster has much more impact on voters than the investment of funds for disaster mitigation.

International Decade for Natural Disaster Reduction: 1990 - 1999:

International Decade for Natural Disaster Reduction (1990-1999)

On 11 December 1987 at its 42nd session, the General Assembly of the United Nations designated the 1990's as the International Decade for Natural Disaster Reduction (IDNDR). The basic idea behind this proclamation of the Decade was and still remains to be the unacceptable and rising levels of losses which disasters continue to incur on the one hand, and the existence, on the other hand, of a wealth of scientific and engineering know-how which could be effectively used to reduce losses resulting from disasters.

The main objective was to minimize loss of life and property, economic and social disruption caused by the occurrence of natural disasters.

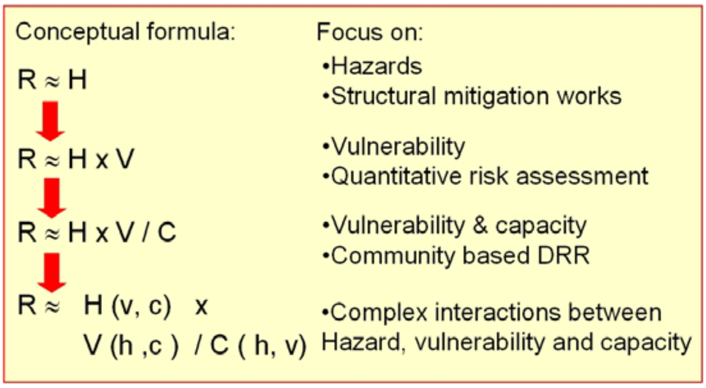


Figure 1.10: Shift in paradigm on disaster risk management. From a hazard centered approach to an approach that recognizes the complex interaction between hazards, vulnerability and capacity of communities at risk. (Source: Thea Hillhorst, Disaster Studies Wageningen.)

The past decades have witnessed a shift in focus from 'disaster recovery and response' to 'risk management and mitigation'. The change was also from an approach that was focused primarily on the hazard as the main causal factor for risk, and the reduction of the risk by physical protection measures to a focus on vulnerability of communities and ways to reduce those through preparedness and early warning. Later also the capacities of local communities and the local coping strategies were given more attention. The Yokohama conference in 1994 put socio-economic aspects as component of effective disaster prevention into perspective. It was recognized that social factors, such as cultural tradition, religious values, economic standing, and trust in political accountability are essential in the determination of societal vulnerability. In order to reduce societal vulnerability, and therewith decrease the consequences of natural disasters, these factors need to be addressed. The ability to address socio-economic factors requires knowledge and understanding of local conditions, which can – in most cases - only be provided by local actors.

From 1990-2000 the International Decade for Natural Disaster Reduction (IDNDR) and now its successor the International Strategy for Disaster Reduction (ISDR) stress the need to move from top-down management of disaster and a cycle that stresses rehabilitation and preparedness, towards a more comprehensive approach that tries to avoid or mitigate the risk before disasters occur and at the same time fosters more awareness, more public commitment, more knowledge sharing and partnerships to implement various risk reduction strategies at all levels (UN-ISDR, 2005). This more positive concept has been referred to as 'risk management cycle', or 'spiral', in which learning from a disaster can stimulate adaptation and modification in development planning rather than a simple reconstruction of pre-existing social and physical conditions (See figure 1.11).

The ISDR aims at building disaster resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development, with the goal of reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters. The World Conference on Disaster Reduction was held in 2005 in Kobe, Hyogo, Japan, and adopted the present Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. The main priorities for action are indicated below.

Hyogo framework for action 2005-2015.

ISDR Priorities for action:

1. Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation;
2. Identify, assess and monitor disaster risks and enhance early warning;
3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels;
4. Reduce the underlying risk factors;
5. Strengthen disaster preparedness for effective response at all levels.

Task 1.8: Video (duration 10 minutes)
Everybody's business: the video explaining the Hyogo Framework for Action.
Watch the video: http://www.youtube.com/watch?v=OR733gGIFdA
For more information:
http://www.unisdr.org/eng/hfa/hfa.htm
A summary of the Hyogo framework for action is also provided on the course DVD.

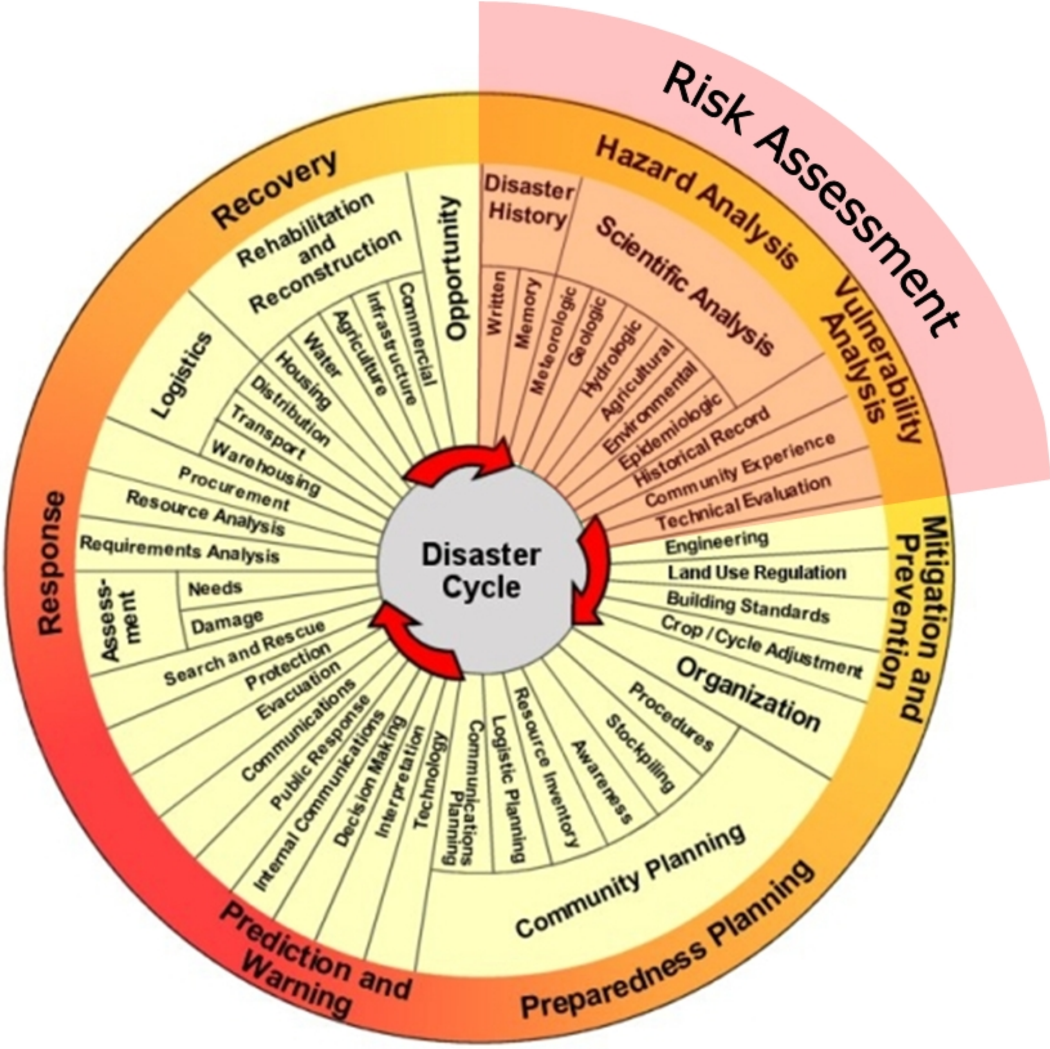


Figure 1.11: The "traditional" disaster cycle and the role of risk assessment.

A general strategy for disaster risk reduction must firstly establish the risk management context and criteria, and characterize the potential threats to a community and its environment (hazard); secondly it should analyse the social and physical vulnerability and determine the potential risks from several hazardous scenarios in order to, finally, implement measures to reduce them (see Figure 1.11). The final goal, reduction of disaster risk in the present and control of future disaster risk, should be achieved by combining structural and non-structural measures that foster risk management as an integrating concept and practice which are relevant and implemented during all stages of a community's development process and not just as a post-disaster response. Disaster risk management requires deep understanding of the root causes and underlying factors that lead to disasters in order to arrive at solutions that are practical, appropriate and sustainable for the community at risk (UN-ISDR, 2005).

Evidently, managing risk in this manner requires a consensual and collaborative approach. The UN-ISDR has widely advocated for new ways in which authorities, communities, experts and other stakeholders jointly diagnose problems, decide on plans of action and implement them. In other words, a new ethic of disaster risk management is emerging, based on 'informed consent' as opposed to paternalism. Risk assessment as the starting point for further risk management processes should in turn be a multifaceted activity aimed at integrating the likelihood and potential consequences of an event with subjective interpretations (perceptions) of interacting, heterogeneous actors.

1.3 Risk assessment

The term Risk is a rather new term. It is originally derived from the Arabic word "رزق", (rizk), which means 'to seek prosperity'. In the middle ages the word "risicum" was used in relation to sea trade and the legal problems of loss and damage. In the English language the word risk was used starting in the 17th century. According to Wikipedia (http://en.wikipedia.org/wiki/Risk) "*Scenario analysis matured during Cold War confrontations between major powers, notably the U.S. and the USSR. It became widespread in insurance circles in the 1970s when major oil tanker disasters forced a more comprehensive foresight. The scientific approach to risk entered finance in the 1980s when financial derivatives proliferated. It reached general professions in the 1990s when the power of personal computing allowed for widespread data collection and numbers crunching.*"

Risk is a term that has become a part of our society and it is used in many different fields, such as:

- **Business and financial risk**: in finance, risk is the probability that an investment's actual return will be different than expected, something that we have experienced recently in the financial crisis of 2008/2009. Basically the stock market is a risk-increasing investment, where you invest money with the hope of a large return, but with the possibility (risk) of losing it. In contrast, putting money in a bank at a defined rate of interest is a risk-averse action that gives a guaranteed return of a small gain and precludes other investments with possibly higher gain.
- **Insurance**: insurance is a risk-reducing investment in which the buyer pays a small fixed amount to be protected from a potential large loss.
- **Health**: risk concepts are used extensively in human-health studies, particularly in the fields of toxicology and epidemology.
- **Engineering**: for instance in nuclear power or aircraft industries the concept of risk is extremely important. But also in all kinds of other engineering projects, for instance in construction engineering of large infrastructural works.
- **Natural hazards**: this is the field that we will look at mainly in this course.

The Risk Assessment approach adopted in RiskCity is based on the definitions from UN-ISDR.

Definition of risk

- the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between (natural, human-induced or man-made) hazards and vulnerable conditions

Definition of risk assessment:

- A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, livelihoods and the environment on which they depend.

  (Source UN-ISDR: http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm)

  The process of conducting a risk assessment is based on a review of both technical features of hazards such as their location, intensity, frequency/probability and also the analysis of the physical, social, economic and environmental dimensions of vulnerability and exposure, while taking into account of the coping capacities pertinent to the risk

UN-ISDR defines risk in short as "the probability of losses". Risk can presented conceptually with the following basic equation (see also Table 1.? And Figure 1.?):

Risk = Hazard * Vulnerability * Amount of elements-at-risk [1]

and the more conceptual equation:

Risk = Hazard * Vulnerability / Capacity [2]

In the RiskCity training package both equations are used. Equation [2] is only conceptual, but allows incorporating the multi-dimensional aspects of vulnerability, and capacity, which are often integrated with hazard indicators using Spatial Multi-Criteria Evaluation. Equation [1], given above, is not only a conceptual one, but can also be actually calculated with spatial data in a GIS to quantify risk, with a focus on (direct) physical, population and economic losses.

Table 1.3: Summary of definitions used in the GIS-based risk assessment (based on IUGS, 1997; UN-ISDR, 2004).

Term	Definition
Natural hazard	A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. This event has a probability of occurrence within a specified period of time and within a given area, and has a given intensity.
Elements-at-risk	Population, properties, economic activities, including public services, or any other defined values exposed to hazards in a given area". Also referred to as "assets". The amount of elements at risk can be quantified either in numbers (of buildings, people etc), in monetary value (replacement costs, market costs etc), area or perception (importance of elements-at-risk).
Exposure	Exposure indicates the degree to which the elements at risk are exposed to a particular hazard. The spatial interaction between the elements at risk and the hazard footprints are depicted in a GIS by simple map overlaying of the hazard map with the elements at risk map.
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. Can be subdivided in physical, social, economical, and environmental vulnerability.
Capacity	The positive managerial capabilities of individuals, households and communities to confront the threat of disasters (e.g. through awareness raising, early warning and preparedness planning).
Consequence	The expected losses in a given area as a result of a given hazard scenario.
Risk	The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between (natural, human-induced or man-made) hazards and vulnerable conditions in a given area and time period.

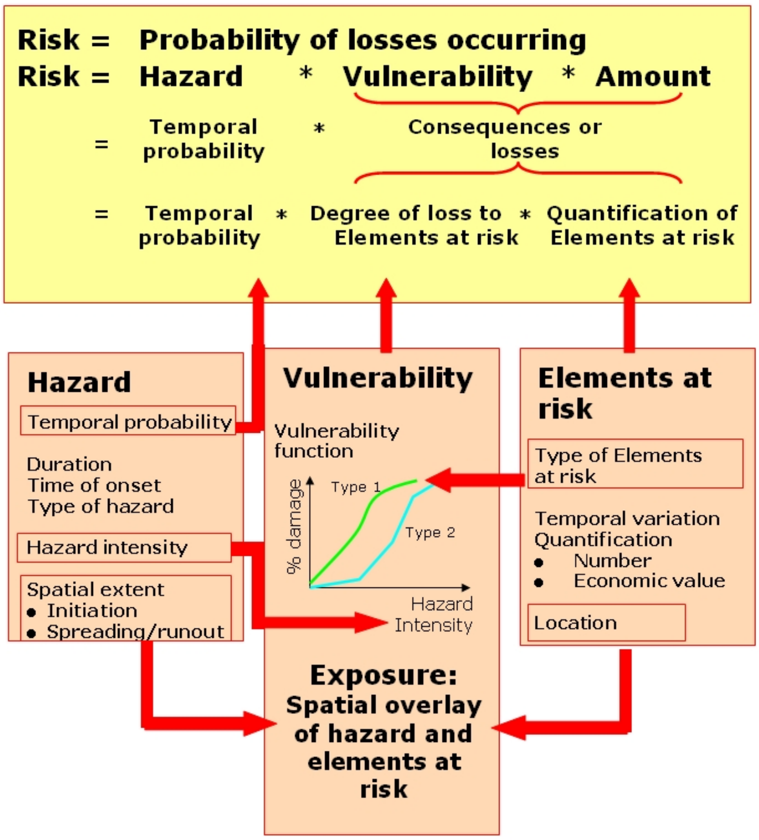


Figure 1.12: Basic function of risk, which can be divided into the components of hazard, the vulnerability, and the amount of elements at risk that are exposed to the hazard.

As illustrated in Figure 1.12 there are two important components, which also should be spatially represented: **hazards** and **elements at risk**. They are characterized by both spatial and non-spatial attributes. Chapter 2 explains the spatial data requirements for hazard and elements-at-risk data, and how available data from the internet can be used.
Hazards are characterized by their **temporal probability** and **magnitude** or **intensity** derived from frequency magnitude analysis (this will be treated in chapter 3). In this respect magnitude and intensity can be considered as synonymous terms that express the severity of the hazard. For instance flood depth, flow velocity, and duration in the case of flooding. For earthquakes the terms magnitude and intensity do have a different meaning, with magnitude expressing the energy level of the earthquake (on the Richter scale) and intensity expressing the local effects of the earthquake, that vary over a distance, becoming less further from the epicenter (and expressed in qualitative classes such as the Modified Mercalli Intensity). The hazard component in equation [1] actually refers to the probability of occurrence of a hazardous phenomenon with a given intensity within a specified period of time (e.g. annual probability). Hazards also have an important spatial component, both related to the initiation of the hazard (e.g. a volcano) and the spreading of the hazardous phenomena (e.g. the areas affected by volcanic products such as lava flows). Chapter 3 gives an overview of the approaches that can be used for the analysis of the temporal and spatial components of hazards.
Elements at risk are the population, properties, economic activities, including public services, or any other defined values exposed to hazards in a given area. They are also referred to as "**assets**". Elements at risk also have spatial and non-spatial characteristics. First of all there are many different types of elements at risk (which will be treated in chapter 4) and they can be classified in various ways. The way in which the amount of elements-at-risk are characterized (e.g. as number of buildings, number of people, economic value or the area of qualitative classes of importance) also defines the way in which the risk is presented.
The interaction of elements at risk and hazard defines the **exposure** and the **vulnerability** of the elements-at-risk. Exposure indicates the degree to which the elements at risk are exposed to a particular hazard. The spatial interaction between the elements at risk and the hazard footprints are depicted in a GIS by simple map overlaying of the hazard map with the elements at risk map.

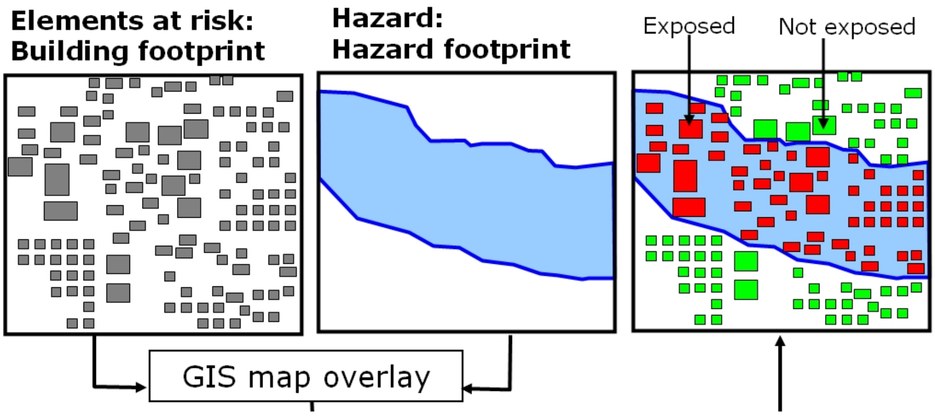


Figure 1.13: Spatial overlay of hazard footprints and elements at risk provides information on exposure.

Vulnerability refers to the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. Vulnerability can be subdivided in physical, social, economical, and environmental vulnerability. The vulnerability of communities and households can be based on a number of criteria, such as age, gender, source of income etc. which are analyzed using equation [2]. However, according to equation [1] vulnerability is evaluated as the interaction between the intensity of the hazard and the type of element-at-risk, making use of so-called **vulnerability curves**.
The concept of vulnerability and the generation of vulnerability curves will be treated in chapter 5, including the use of participatory methods for community-based risk assessment.
The spatial interaction between elements-at-risk and hazard footprints, which is often referred to as "exposure" in other risk formulas, is an integral component of GIS-based risk assessment, and therefore the term exposure is not used as such in the risk equation. When we calculate the risk equation using a Geographic Information System (GIS) the elements

at risk that are exposed to the hazards are automatically obtained using map overlaying techniques. This is illustrated in Figure 1.13.

Task 1.9: Question (duration 5 minutes)

Check the figure 1.13. How much would be the risk using the equation [1] if we assume that:

- *the hazard event has a Return Period of 100 years*
- *the buildings in the hazard footprint zone would suffer 10 percent damage*
- *each building would cost 100.000 Euro?*

1.4 The RiskCity case study

The RiskCity training package focuses on demonstrating the procedures of risk assessment for natural and human-induced hazardous phenomena in an urban environment within a developing country. We have selected an urban area, because the elements at risk have a much higher density, the study areas are generally smaller and the scale of analysis larger as compared to a rural setting. This allows us to demonstrate which tools can be used for generating hazard as well as elements at risk databases, even in data poor environments, and to show how qualitative and quantitative techniques for risk assessment can be used, and in which situation. Also the combined effect of different hazard on the overall risk can be better demonstrated, as well as the effect of risk reduction measures. Figure 1.14 gives a schematic overview of the steps that will be followed in the Riskcity exercises. We will look at four different hazards: flooding, landslides, earthquakes and technological hazards. Future flood scenarios were modelled using two different models: HEC-RAS and SOBEK. Due to time limitations we will not be working with the actual models but use GIS for input and output. Landslide hazard assessment was carried out in the RiskCity case study using two different approaches: a combined statistical/heuristic analysis and physical modeling. Earthquake hazard assessment is done using empirical attenuation curves. Technological hazards are analyzed using effect distance formulae which are empirically derived.

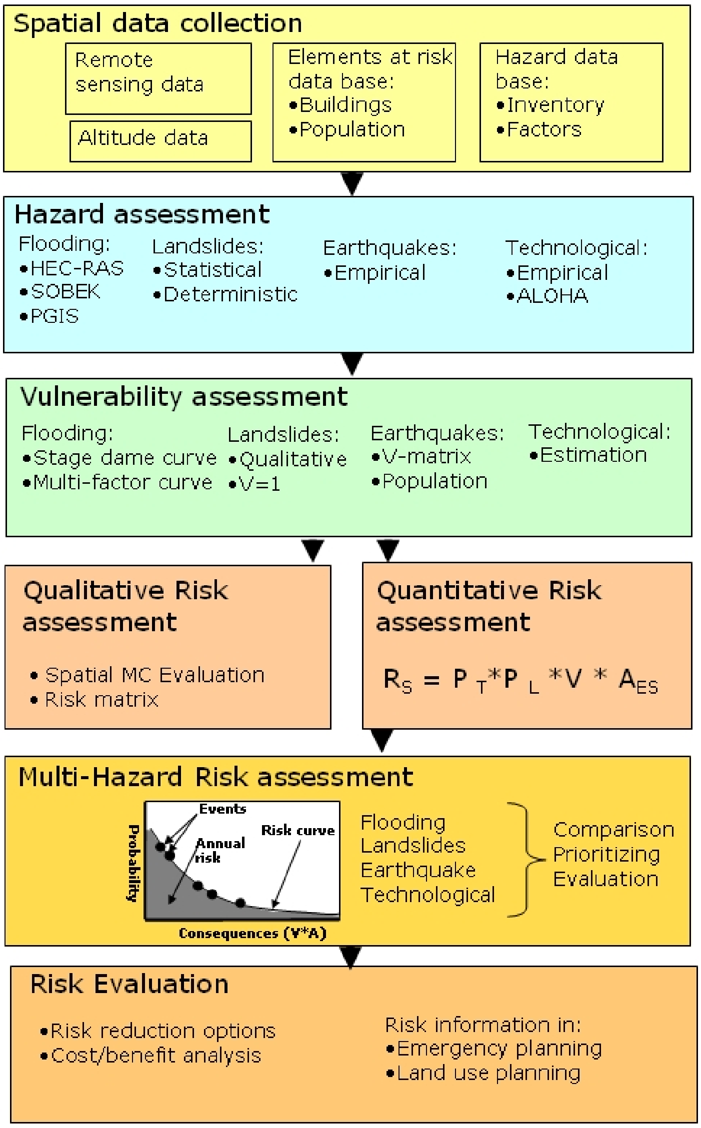


Figure 1.14: Overview of the steps used in the RiskCity case study for multi-hazard risk assessment. The abbreviations mentioned in the hazard assessment part are explained in session 3.

For each of the four hazard types the vulnerability will be analyzed using different approaches. Risk assessment will be done using a qualitative approach with spatial multi-criteria evaluation, and a quantiative approach using risk curves.

1.4.1 About the study area.

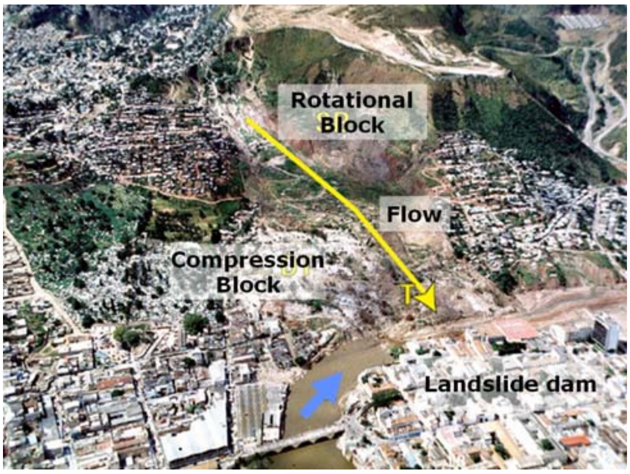


Figure 1.15: Overview of the hazard event with a landslide that dammed the river. Source: R. Peñalba

To illustrate some of the aspects discussed in this chapter for RiskCity, this section shows a number of examples related to landslides and flooding in RiskCity. As mentioned before the city of Tegucigalpa, Honduras was taken as the basis for RiskCity. It should be kept in mind that the material is for training purposes and has been adapted, and therefore is not a direct example for the city of Tegucigalpa. Therefore we will refer to it consistently as RiskCity from now on. Figure 1.15 shows an example of a large landslide, named El Berrinche, in the centre of the city of RiskCity. This landslide occurred in late October 1998, as a result of heavy rainfall and undercutting of the toe by the Choluteca River, during the passing of hurricane Mitch. RiskCity is located in a bowl shaped valley, underlain in the SE by a formation, consisting of red sandstone, siltstone and some conglomerates, and Tertiary volcanic deposits in the northwestern part. The highest parts of the area are plateaus underlain by ignimbrites with steep cliffs around their edges and a complex series of old landslides, which have not been dated till now. One of these is the El Berrinche landslide (see figure 1.15), which is approximately 700 meter long and 400 meter wide. The landslide has had several phases of activity over the last decades, which culminated in the massive failure on October 31 1998. The movement history can be reconstructed with the help of image interpretation, utilizing aerial photographs, satellite images and LiDAR data from different periods. On an airphoto from 1974, the paleo landslide can be clearly recognized, and a reactivation which occurred in the toe of the landslide in 1970 is evident. During this period also the houses on top of the old landslide were already constructed, road construction in the higher parts suggests that further development was planned, which was never implemented. A second reactivation took place in 1984, which produced considerable damage to roads and houses in the area. The first signs of what later would form into an earthflow can be identified on the aerial photo from 1990, as well as the depressions in the upper part of the landslide. After a geotechnical investigation the area was declared unsafe and further development was not considered appropriate. The main movement occurred in October 1998, and the aerial photo taken just after this clearly shows the different components of the landslide consisting of a rotational block in the upper part, an earthflow in the center and a compressional toe. The landslide had a volume of 6 million cubic meters, and most houses of the Colonia Soto were ruined as well as parts of the adjacent neighborhoods. The landslide dammed the Choluteca River leading to extensive flooding in the center of Tegucigalpa for a number of weeks. After the event the slope was flattened and a series of benches were constructed along the toe (See Figure 1.16).

In the case of RiskCity several types of remote sensing data were used. Aerial photographs for several periods, including the period of the major disaster event in 1998, and two sets of satellite data from 2001 and 2006 were the basis for landslide mapping. High resolution satellite data was used for mapping elements-at-risk, and medium resolution Aster data for generating a land use map of the area. Figure 1.16 gives an illustration of some of the remote sensing data used in the case study of RiskCity. Elements-at-risk data can be obtained at different levels of detail. In the RiskCity case study this is done at the urban level, where information needs to be as detailed as possible, preferably at the individual building level, or at a slightly more aggregated level of mapping units or building blocks with homogenous land use and building type. In the RiskCity case study two different situations with respect to the availability of input data were simulated: a situation where the database should be constructed from scratch and a situation in which already detailed spatial and attribute information is available.

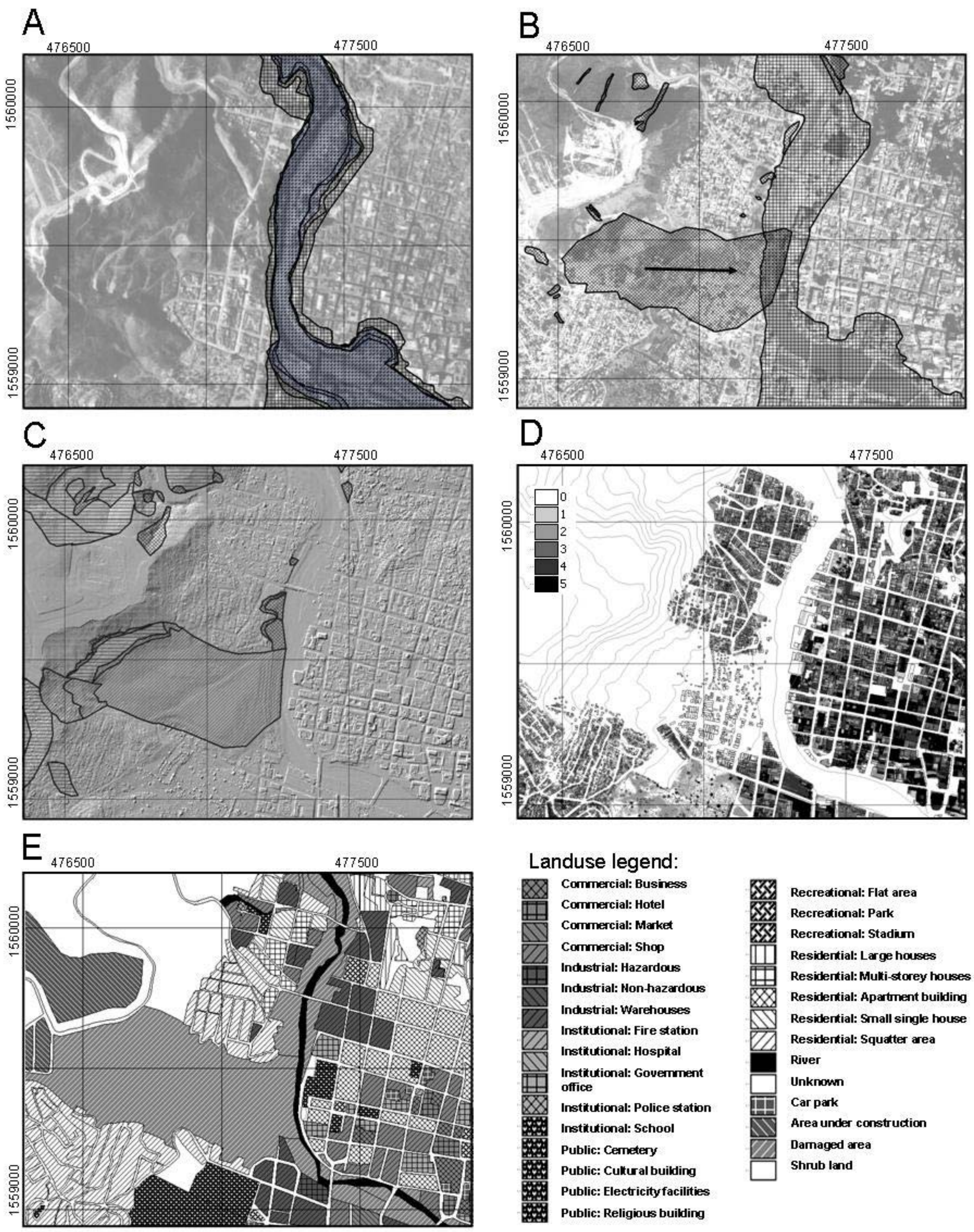


Figure 1.16: Different types of spatial information for risk assessment in the case study of RiskCity. A: Airphoto from 1977 with flood scenarios of different return periods, B: Post disaster airphoto of 1998 with flood and landslides, C: Hillshading of LiDAR DSM with landslide inventory, D: Building height, in number of stories, from LiDAR DSM and building footprint map E: Mapping units, representing zones of more or less homogeneous urban landuse and building types, with land use classification

This course aims at showing you how spatial data or geo-information can be used in a multi hazard risk assessment. The definition of geoinformation is:

> Geo-information science and earth observation consists of a combination of tools and methods for the collection (e.g through aerospace survey techniques), storage and processing of geo-spatial data, for the dissemination and use of these data and of services based on these data.

In order to be able to utilize geo-information for risk assessment, you will need specific tools. The next session deals with the tools that we will use in the course.

1.5 The tools: WebGIS and GIS

This course uses Geographical Information Systems for the multi-hazard risk assessment. During more than half of this course you will be working with GIS. However, this is not a GIS course. You also don't need to be a GIS expert in order to follow this course. Since we are using GIS tools that are easy to learn and use, we will focus entirely on what you can do with GIS for risk assessment and not on the tool as such.

> If you want to get more technical information on GIS we recommend you to follow the ITC distance education course on GIS. For information and registration please visit: http://www.itc.nl/education/courses.aspx

The course is designed in such a way that even non-GIS specialist can follow the course, since the instructions are describing the steps you need to take in a cook-book manner, at least in the initial phases. In the later part of the course, when you are more used to the ILWIS software there will be also exercises where you have to evaluate yourself the steps needed for an analysis.
The course is designed in such a way that you can also follow it if you are not able or willing to use the ILWIS GIS for the exercises. This may be the case if you are not that much interested in the particular steps to follow in a risk assessment, but want to know more about the overall procedure and the things you can do with the (intermediate) results. Therefore we have made the two following options with respect to the exercise part of the course:

- **The GIS version**. This is the standard option for using the course materials. You will be working with the Open Source GIS software ILWIS, and you will learn the individual steps to make a hazard assessment, elements at risk database, vulnerability assessment, qualitative and quantitative risk assessment, and how to use the risk information for (preparedness) planning. You follow the instructions in this theory book, and when the book contains a task (indicated in a green box that refers to one of the RiskCity GIS exercises) you then go to the exercise part of the book and follow the instructions there. You will use the GIS data for that particular exercise provided on the course DVD. The duration of the course will then be 6 weeks (distance education version) or 3-4 weeks (fulltime course), depending on the option for doing the final project in session 8.
- **The WebGIS version**. The WebGIS version allows you to evaluate the individual steps of the methodology without actually doing GIS analysis. You will not use ILWIS, but will use the WebGIS version that is also included on the course DVD. The WebGIS exercises will take much less time than the GIS version. They have separate exercise descriptions.

1.5.1 WebGIS

The aim of the WebGIS version of RiskCity is as follows:

- To illustrate the steps that will be carried out in each of the RiskCity exercises. The participants of the course can first follow the WebGIS version and see the main idea of the exercise before they actually do the exercise with ILWIS.
- In session 7 on risk management, we include one subchapter on WebGIS and its advantages, and then use the WebGIS version of RiskCity as an illustration of the possibilities of WebGIS for disaster risk assessment and management.
- The WebGIS version of RiskCity can also be used in short courses on Multi-hazard risk assessment focused on decision makers rather than technical staff. The decision makers do not have to know all individual steps of the procedure, and normally also do not have the time or background to do that. So we replace the RiskCity exercises by the WebGIS exercises for them. In this case we use 6 exercises that take about 2-3 hours each and that can be used in a short course of 1 week, together with a selection of the theory materials of RiskCity.

In addition to exercises offered by the RiskCity training package, a WebGIS version has been developed. The purpose is to offer the student an overview of the real benefits of this kind of instrument following the topics of the package and to give a general idea of data management results obtained in every exercise.

A WebGIS is an Internet GIS Application, a platform for sharing spatial and geographical data using the web. The traditional stand-alone GIS tools are fixed and gathered to the client by web, removing every need of software installation and setup. RiskCity database and browser are connected through some protocols: WebRiskCity network offers a series of webservices at server-side in which maps and spatial information are updated and organized to allow exploiting by users on the client-side. The solution used for WebRiskCity is built on OpenSource Cartoweb3, a ready-to-use WebGIS based on UMN Mapserver engine and released under GNU GPl License. The architecture of the platform is based on a core navigation interface (map and navigation) and other tools are activated by the user (map query, annotation and labeling, measuring, PDF creation and other export formats, help session support and expected activity text for every exercise).

A simplified version of RiskCity dataset is offered. Spatial data are available for different interactions: the user can personally evaluate the type and the resolution of result data archived for every exercise session, compare different kinds of information in a multi hazard-risk assessment, prepare queries according to exercise aims, download information tables for outside elaboration, create his personal layout with new shapes and labels directly drawn on map. WebRiskCity allows the users to learn different levels of risk assessment without actually executing all steps by themselves. The structure of the application is based on a complex hierarchy of layers, by which all users can compare different types of information and analyze a specific part of the City in several ways. All the maps are organized in sessions that can be accessed through switches at the bottom of the screen. Inside each one the activities and tasks required are made easier by using blocks, drop-down menus and exclusive options. Seven switches are used, following the same order of the sessions of this book.

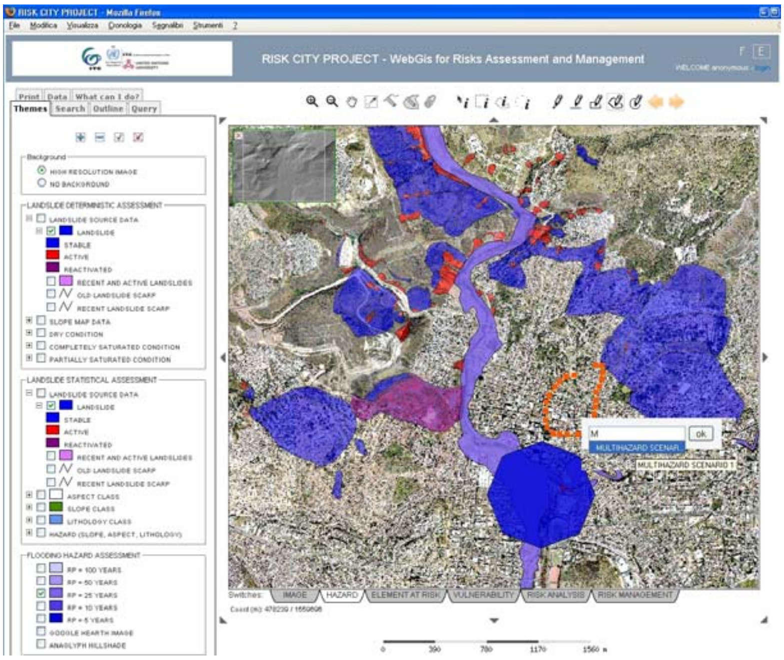


Figure 1.17: Overview of the WebRiskCity screen.

Besides a support for the RiskCity package, the platform is a direct user-friendly device for technicall staff and decision makers that normally do not have a background in Geoinformatics in Risk Analysis and Management. The instrument helps to identify the multirisk reality of the study area, to present the more “sensible” parts of the city that are prone to different kinds of hazards, to show the comparison between different maps and to understand the values and flaws of different kinds of approach on Risk management.

Task 1.10: WebGIS exercise: introduction to RiskCity (duration 1 hour)

Go to the WebRiskCity exercise 1 which deals with the introduction of the dataset, and follow the instructions.

If you also will do the GIS exercise (Task 1.11) you may also decide to skip this exercise now.

1.5.2 GIS

The other tool for handling geo-informatin that we will use extensively during this course is a Geographic Information System. The box on the next page gives a general introduction to GIS. If you are completely new to GIS you might find it rather difficult (although not impossible) to follow this course as it contains 50 percent of GIS related practicals. In that case you might have to use some more time for the practicals, and perhaps do less of them.

What is GIS?

- A Geographic Information Systems is a computerized system for collecting, storing, managing, analyzing and visualizing spatial information and related non-spatial data . The ultimate purpose of GIS is to provide support for decision making based on spatial data.

What is spatial information?

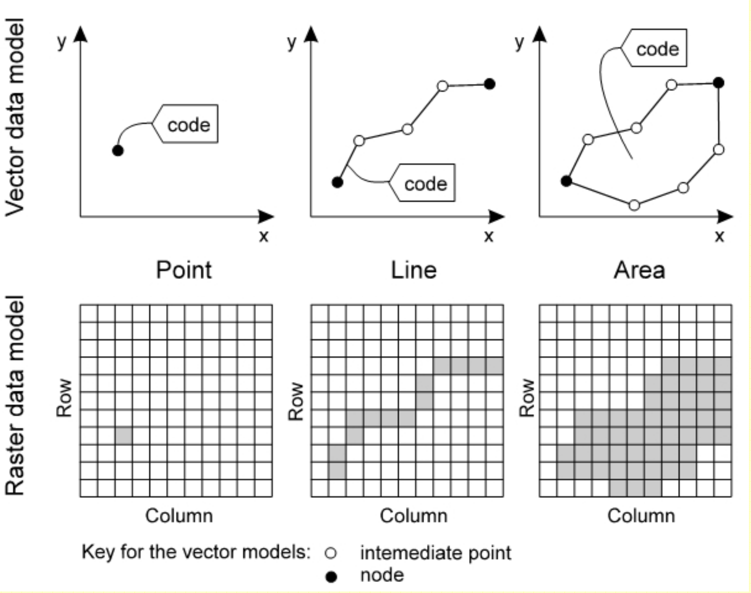
- Spatial information is information about a particular location on earth. It is information that has (X and Y) coordinates. Coordinates define where a point, line or area is on earth.

How are coordinates obtained?

- Coordinates are defined as either geographical coordinates or metric coordinates. Geographical coordinates are indicated in degrees, minutes and seconds. Metric coordinates are indicated in X,Y (and sometimes also altitude Z) in relation to a projection of the curved surface of the earth on a plane surface. Every country has its own projection system, but the Universal Transverse Mercator projection (UTM) is often used internationally. Coordinates can be obtained from existing maps, or through Global Positioning Systems (GPS).

Spatial data types:

- Spatial data can be stored in various ways. The main difference is between vector data (in which points, lines, and polygons are stored as points and connections of points with their X and Y and label) and raster data (in which the area is divided into regular cells called pixels with a certain size). Remote sensing data (satellite images) are always in raster format. Thematic data (e.g. contourlines, land use, geology) are digitized as vector data, but they can be converted to raster.



GIS components:
The general purpose geographic information systems essentially perform six processor tasks:

- **Input** . The entry of spatial data is through scanning of maps or images (the data is then in raster format), conversion from other digital formats, or digitizing (normally a map is first scanned and digitizing is done on the screen)
- **Manipulation**: data needs to be georeferenced (attaching the right coordinates to it), properly edited, and linked to non-spatial data (which are normally in the form of tables).
- Management: the data needs to be properly managed, documented (using Metadata which describe what the data is), updated and shared with other users (e.g. through an internet based Spatial Data Infrastructure)
- **Query:** querying is consulting the spatial data in order to find information on a specific location (what is?) or find the locations that meet a certain criteria (where are..?). A query allows the users to consult different types of data simultaneously.
- **Analysis**: Analysis is the process of inferring new meaning from data. Data analysis is the core of a GIS. It allows to use the spatial and non-spatial data for problem solving. Analysis in GIS can also be carried out using a series of operations such as measurement (calculating how large, how long how many), overlay operations (combination of two or more maps e.g. through joint frequency or cross tables), and neighboirhood operations (which calculate things based on the characteristics of neighboring areas). GIS analysis can be linked to models either inside GIS or with external models that use GIS for input and output.
- **Output and Visualization**: the results of the analysis should be properly visualized using cartographic tools of a GIS (combining thematic data with topographic data, adding legends, scale bars, etc) or using WebGIS which allows visualizing data through internet.

GIS software

- There are many different software packages available for GIS analysis. The standard is ARCGIS, which is a commercial software. Non-commercial software is also widely available such as ILWIS or GRASS.

As mentioned in Session 0 we are using an Open Source GIS software in this course. ILWIS is an Open source GIS and image processing software developed by ITC. There are many more Open Source GIS software packages available. For a list of these please visit: http://opensourcegis.org/

There is one software we would like to mention specifically : PCRaster. The PCRaster Environmental Modelling language is a computer language for construction of iterative spatio-temporal environmental models. It runs in the PCRaster interactive raster GIS environment that supports immediate pre- or post-modelling visualisation of spatio-temporal data. The software was developed by the University of Utrecht (The Netherlands). It can be downloaded from: http://pcraster.geo.uu.nl/. PCRaster is often used in combination with ILWIS for advanced modeling applications.

Task 1.11: GIS exercise: introduction to ILWIS and RiskCity (duration 3 hours)

Now that you have had the introduction on the method, the riskcity case study and ILWIS, it is time to start working with it.
Find the exercise description of exercise 01: Introduction to RickCity and follow the materials using the spatial data that is provided on the DVD.

- *You can find the GIS data in a Zipped file in the directory:* ***:\RiskCity exercises\01 Intro RiskCity\Data***
- *Make a directory on your harddisk:* ***\Riskcity data\01 intro***
- *Unzip the data into this directory.*
- *Go to the exercise text and follow it from there by starting up ILWIS.*

Table: overview of the session and related RiskCity exercises.

Session		RiskCity exercise
1. Introduction to Risk Assessment		Exercise 1: Introduction to ILWIS and the Riskcity dataset
2. Spatial data for risk assessment		Exercise 2: Creating and interpreting multi-temporal images
3. Hazard assessment		Exercise 3a: Frequency assessment
	Choice: flooding	Exercise 3F1: Flood hazard assessment using 2D flood propagation model outputs
		Exercise 3F2: Flood hazard monitoring using multi- temporal SPOT-XS imagery
	Choice landslides	Exercise 3L1. Landslide susceptibility assessment using statistical method
		Exercise 3L2. Deterministic landslide hazard assessment
	Choice: Volcanics	Exercise 3V: Modeling erosion from pyroclastic flow deposits on Mount Pinatubo
	Choice: Earthquakes	Exercise 3E: Earthquake hazard assessment
	Choice: Coastal	Exercise 3C1: Hazard analysis of cyclone flooding in Bangladesh
		Exercise 3C2: Analysis of coastal areas vulnerable to Enhanced Sea Level Rise
		Exercise 3C3: Modeling of Land Subsidence & Sea level rise in Semarang city, Indonesia
4. Elements at risk	Choice options	Exercise 4a: Generating a database of elements at risk from scratch
		Exercise 4b: Generating a database of elements at risk using existing data
		Exercise 4c: Participatory GIS for risk assessment.
5. Vulnerability assessment		Exercise 5a. Generating vulnerability curves
		Exercise 5b. Spatial Multi Criteria Evaluation for vulerability and qualitative risk assessment
6. Risk Assessment	Choice options	Exercise 6F: Flood risk assessment
		Exercise 6L: Landslide risk assessment
		Exercise 6S: Seismic risk assessment
		Exercise 6T: Technological risk assessment
		Exercise 6M : Multi-hazard risk assessment
7. Risk Management		Exercise 7b: Risk information for emergency preparedness & response
		Exercise 7a. Analysis of costs & benefits of risk reduction scenarios
8. Final project		Select a topic from a list and carry out your own analysis

Selftest

In order to evaluate whether you have understood the concepts that were presented in this session. Please make the following test, and check the answers in Blackboard.

Question 1.1: Disaster occurrence
Disaster losses have shown an increase over the last 60 years with a factor of 7 and the number of disasters an increase with a factor of 2.5. This is caused mainly by:

A) Better reporting of disasters in the media, and an increase in technological disasters due to climatic change.
B) Population increase, combined with an increase of geological events due to increased tectonic activity.
C) Increased vulnerability of societies and population growth, combined with an increase in hydro-meteorological extreme events.
D) Economic decrease and technological development combined with a better risk management.

Question 1.2: Risk definition
Which definition of risk is **not** correct?

A) The term risk refers to the expected losses from a given hazard to a given set of elements at risk, over a specified future time period.
B) Risk can be expressed mathematically as the probability that a hazard impact will occur multiplied by the consequences of that impact.
C) Risk is the expected number of lives lost, persons injured, damage to property, or disruption of economic activity due to natural or man induced phenomena.
D) Risk is a serious disruption of the functioning of a community or society causing widespread human, physical, economic and environmental losses, that exceed the capacity of that community or society to cope using its own resources.

Question 1.3: Disaster risk management
Hazard and risk maps are used in the following phase of disaster risk management:

A) Disaster prevention.
B) Disaster preparedness.
C) Disaster response.
D) All of the above.

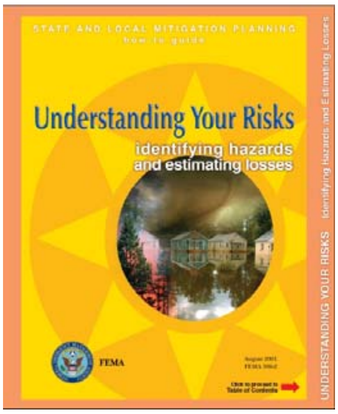
Question 1.4: Climate change and risk
Which of the following statements is true?
The effects of climate change on risk are expected to be highest in these areas because of:

A) Pacific islands because of changes in local risk of extremes
B) Desert areas because of changes in average climate
C) Desert areas because of changes in local risk of extremes
D) Pacific islands because of changes in average climate

Question 1.4: disaster statistics
The official CRED disaster database often does not contain the correct information on all types of disasters, because:

A) Disasters that happen in remote locations are often not well known and therefore mostly overestimated.
B) Many small and frequent events may not pass the thresholds for inclusion in the database.
C) The losses from spectacular disasters, that attract more media, are often overestimated.
D) Disaster losses are often not properly recorded during holidays or weekends.

Further reading:



FEMA guide

There is a very useful guide prepared by FEMA called "Understanding your risks" that guides you through the various phases of a risk assessment. This guide is not ment for the use of GIS, but it is a very useful background reading document. The guide is also in the background materials of the course. You can also access it on: http://www.fema.gov/plan/mitplanning/howto2.shtm

A very relevant textbook on risk assessment is:

Smith, K. and Petley, D.N. (2009). Environmental hazards: Assessing risk and reducing disaster. Routledge, Taylor & Francis Group, London, 383 p.

Relevant background documents on Disaster Risk Reduction are:

Alexander, D. 1993. Natural disasters. UCL Press Ltd., University College, London.

Baas, S., S. Ramasamy, et al. (2008). Disaster Risk Management Systems Analysis A guide book.

Birkmann, Jörn (UNU-EHS): Measuring vulnerability Measuring Vulnerability to Natural Hazards Towards Disaster Resilient Societies. http://www.ehs.unu.edu/article:279

Blaikie, P. (1994). At risk : natural hazards, people's vulnerability and disasters. London etc., Routledge.

O'Keefe, P., Westgate, K. and Wisner, B. (1976). Taking the naturalness out of natural disasters. Nature 260, 566-567.

United Nations-International Strategy for Disaster Reduction (UN-ISDR) (2005). United Nations. Bureau for Crisis Prevention and Recovery. Reducing Disaster Risk: A Challenge for Development. http://www.undp.org/bcpr/disred/rdr.htm

UN (2004). Living with Risk, United Nation

Relevant literature used in developing the materials for RiskCity, based on the orginial situation in Tegucigalpa, Honduras.

JICA, Japanese International Cooperative Agency, 2002, The study on flood control and landslide prevention in the Tegucigalpa metropolitan area of the Republic of Honduras: Japan International Cooperation Agency (JICA) Interim Report, 148 p.

Gutierrez, R. Gibeaut, J.C., Smyth, R.C., Hepner, T.L. and Andrews, J.R. 2001. Precise Airborne Lidar Surveying For Coastal Research and Geohazards Applications. International Archives on Photogrammetry and Remote Sensing, Volume XXXIV-3W4, Annapolis, MD, 22-24 Oct. 2001. 185-192

Harp, E.L., Castañeda, M.R., and Held, M.D., 2002a, Landslides triggered by Hurricane Mitch in Tegucigalpa, Honduras: U.S. Geological Survey Open-File Report 02-33, 11 p., 1 plate.

Harp, Edwin L., Held, Matthew D., Castañeda, Mario, McKenna, Jonathan, P., and Jibson, Randall W., 2002b, Landslide hazard map of Tegucigalpa, Honduras: U.S. Geological Survey Open-File Report 02-219, 9 p., 2 plates.

Mastin, M.C., 2002, Flood-hazard mapping in Honduras in response to Hurricane Mitch: U.S. Geological Survey Water-Resources Investigations Report 01-4277, 46 p.

Olsen, R.S. and Villanueva, E., 2007. Geotechnical Evaluation of the massive El Berrinche landslide in Honduras. In: V.L. Schaefer, R.L. Schuster and A.K. Turner (eds), Proceedings First North American Landslide Conference, Vail, Colorado, USA, June 2007, 738-748.

Peñalba, R.F., Kung, G.T.C. and Juang, C.H., 2007. El Berrinche landslide in Honduras. In: V.L. Schaefer, R.L. Schuster and A.K. Turner (eds), Proceedings First North American Landslide Conference, Vail, Colorado, USA, June 2007, 730-737.

Rogers, R.D. y E.A. O'Conner, 1993, Mapa Geológico de Honduras: Hoja de Tegucigalpa (segunda edicion), Instituto Geográfico Nacional, Tegucigalpa, Honduras, escala 1:50,000.