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METEO-HYDROLOGISCHE RAMPEN EN RISICO-ANALYSE

JANNEKE ETTEMA, VICTOR JETTEN, CEES VAN WESTEN

ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

DEPARTMENT EARTH SYSTEM ANALYSIS AT ITC

Applying relevant geo-information for understanding earth surface and geological processes, the sustainable use of geo resources, and the use of geo-science in the mitigation of natural or man-made damage to our environment.

Chair Prof. Freek van der Meer (Earth Systems Science)
- Georesource exploration
- Geonvironmental engineering
- Geodynamics

Chair Prof. Victor Jetten (Natural Hazards and Disaster Risk Management)
- Geohazard analysis
- Multihazard Risk Assessment
- GI for Disaster Management

24 staff
27 PhD researchers

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DISASTER MANAGEMENT FRAMEWORK

	Rapid disasters	*Slow disasters*
Causes	**Hazards:** Landslides, floods, earthquakes	**Hazards** Erosion and desertification
Effects	**Risk analysis** Vulnerability in urban and rural areas	**Land degradation** long term onsite and off site effects
Response	**Disaster mitigation** Damage assessment, planning, awareness	**Prevention and mitigation** Soil and water conservation

WAT DE INHOUD IS VAN DEZE PRESENTATIE

- Rampen wordt veroorzaakt door zowel het natuurgeweld als onze eigen activiteiten
- Basisprincipes van risico-analyse en management
- Belang van meteorologische en klimatologische gegevens voor begrijpen en voorkomen van natuurrampen

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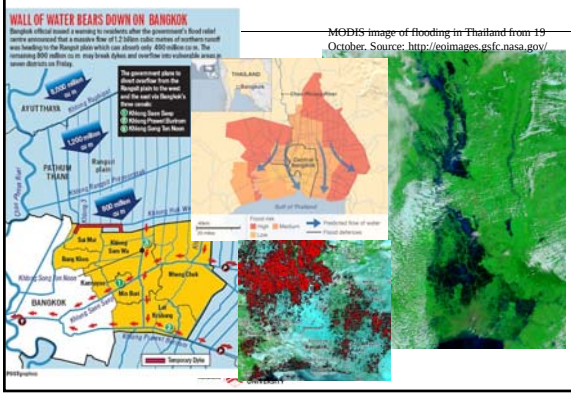
Recent flooding in Bangkok...

Flooding in Thailand



MODIS image of flooding in Thailand from 19 October. Source: http://eoimages.gsfc.nasa.gov/

DAMAGE ESTIMATES (23 OCT)

- Death toll of 350
- About 113,000 people have been relocated to rescue shelters due to the floods.
- 1,743 evacuation centres are open and able to accomodate over 800,000 people.
- Economic losses are estimated to be as much as 60 to 90 billion baht ($ 2.9 million) (Thail government)
- The Federation of Thai Industries (FTI) estimates the cost of damage caused by the floods in the Central Plains region at 190 billion baht ($6.1 billion)
- More than 900 large factories have been shut , affecting more than 200,000 workers

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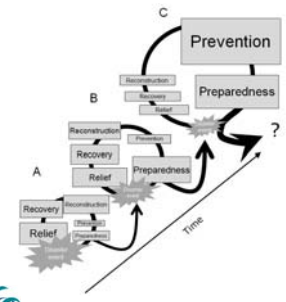
DISASTER MANAGEMENT CYCLE



- Components: relief, recovery, reconstruction, prevention and preparedness.
- Initially most emphasis was given to disaster relief, recovery and reconstruction
- Later more attention was given to disaster preparedness.
- Eventually the efforts are focusing on disaster prevention and preparedness

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A DEFINITION OF DISASTERS

" A serious disruption of the functioning of a community or a society, causing widespread human, material, economic or environmental damage which exceed the ability of the affected community to cope using its own resources." (EEA, 2005)

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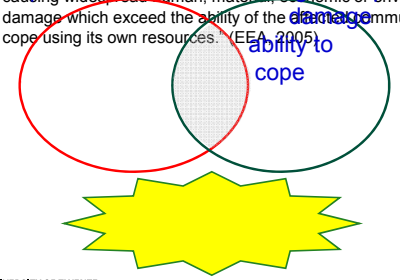
NATURAL HAZARDS AND DISASTERS

serious disruption causing widespread damage ability to cope

" A serious disruption of the functioning of a community or a society, causing widespread human, material, economic or environmental damage which exceed the ability of the affected community to cope using its own resources." (EEA, 2005)



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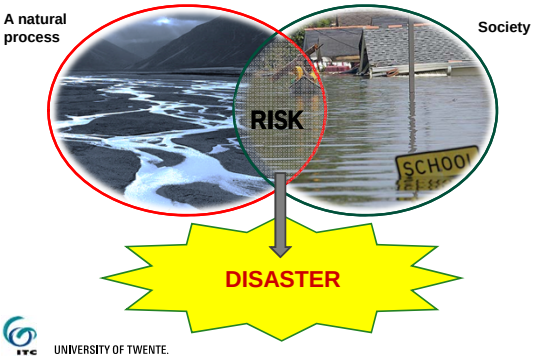
"RISK" IS THE OVERLAP OF A HAZARD AND SOCIETY



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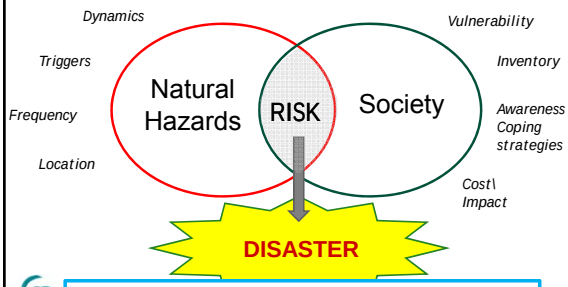
DISASTER RISK MANAGEMENT



Scientific research is about analyzing risk

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WHAT IS RISK?

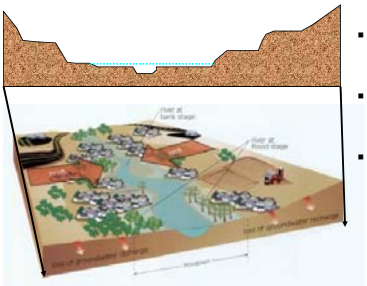
RISK: The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between (natural, human-induced or man-made) hazards and vulnerable conditions.

- How can we assess risk?

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.

RISK CONCEPT

RISK IS A SPATIAL PROBLEM



- Hazard:
  How much water when and where?
- Elements at risk:
  Which elements where, and how many/much ?
- Vulnerability:
  How much water where which elements at risk are?

RISK IS MULTIDISCIPLINARY SPATIAL PROBLEM

Hazard assessment: earth scientists, hydrologists, volcanologists, seismologists, meteorologists

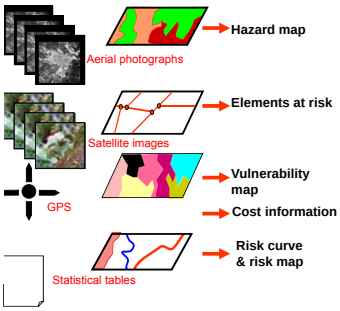
Elements at risk: geographers, urban planners, civil engineers

Vulnerability: depending on type of vulnerability by different scientists from: structural engineers, civil engineers to geographers , social scientists, ecologists

Cost estimation: economists

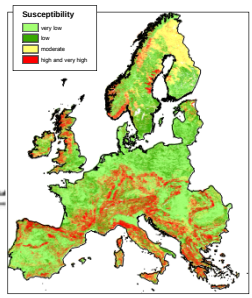
Risk assessment: GIS experts

Risk management & reduction: Decision making: Polititians.



EXAMPLE: FLOOD RISK SUSCEPTIBILITY

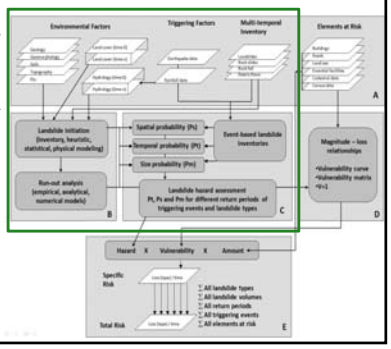
http://floods.jrc.ec.europa.eu/flood-risk.html



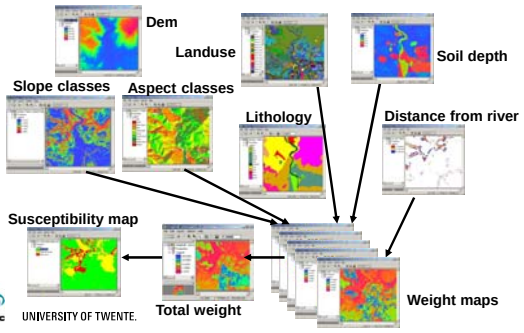
Gunther et al., 2011

RISK ASSESSMENT FRAMEWORK

- A: Basic data sets
  - Static
  - Dynamic
- B: Susceptibility & hazard modelling
- C: Hazard assessment
- D: Vulnerability assessment
- E: Total risk



Environmental factors impacting on susceptibility



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Downstream 2008 flood Reconstruction Naga City

- Water level and timing
- Where (higher/lower areas)
- Residence time / damage (interruption of activities)
- Protection level needed (dikes)

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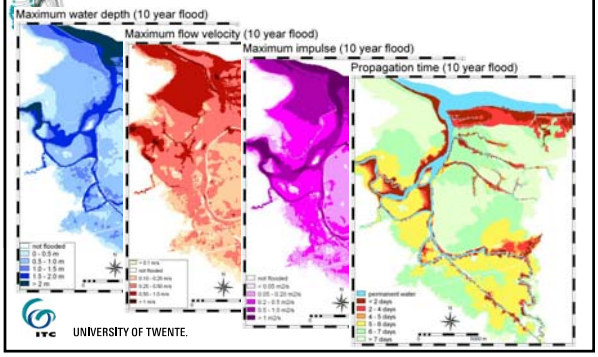
Probability of hazards



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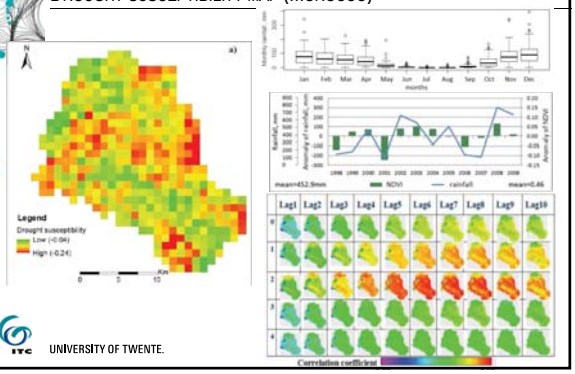
Drought susceptibility map (Morocco)



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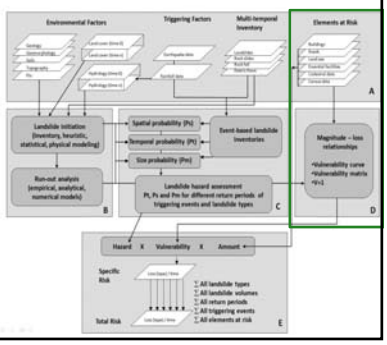
Who is at risk: Vulnerability

- Physical vulnerability: building strength, materials, nr floors etc.
- household composition, education/illiteracy, financial status, gender issues, age etc.
- Also questions on awareness, adaptation, mitigation, risk perception

Risk assessment framework

- A: Basic data sets
  - Static
  - Dynamic
- B: Susceptibility & hazard modelling
- C: Hazard assessment
- D: Vulnerability assessment
- E: Total risk



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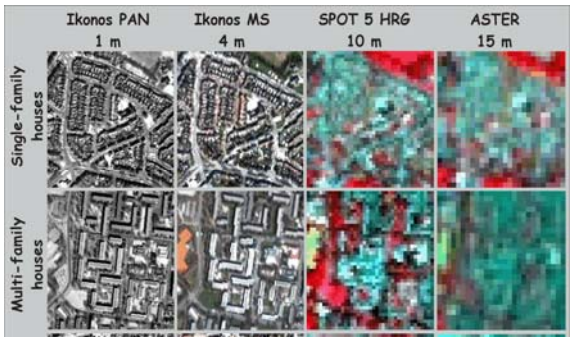
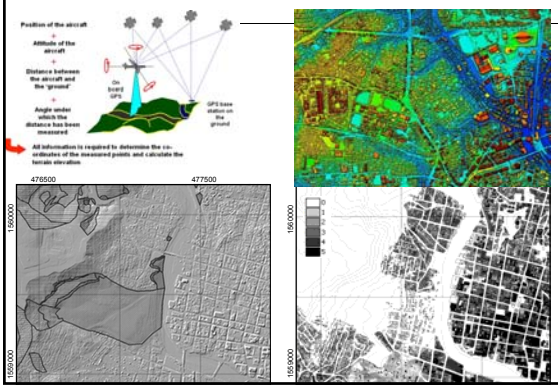
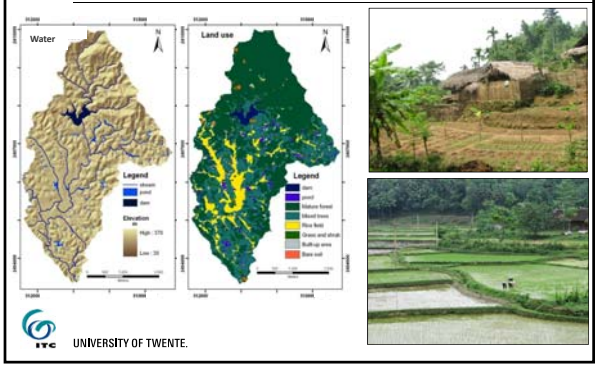
"ELEMENTS AT RISK" INVENTORY



LASER ALTIMETRY AND BUILDING FOOTPRINTS



LAND USE: tea and rice, some deforestation



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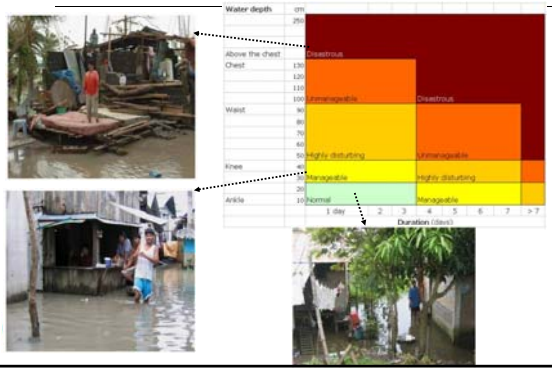
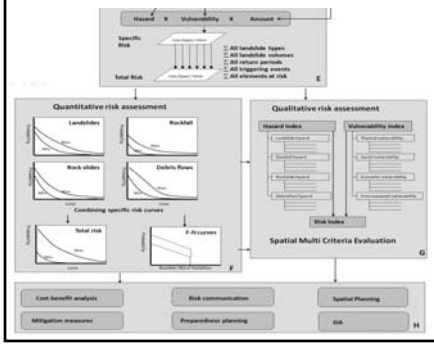
COMMUNITY-BASED CHARACTERISATION OF THE THREAT DURING FLOODING



RISK ASSESSMENT

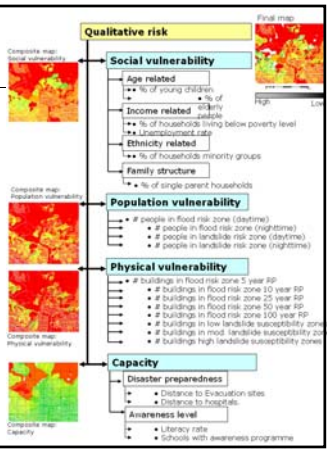


- E: total risk
- Risk assessment
  - F: Quantitative
  - G: Qualitative
- H: Risk evaluation

POPULATION ATTRIBUTES

Depending on the objective of the study:

- Household composition
- Livelihood
- Socio-economic status
- Gender
- Age distribution
- Education
- Combine into indicators



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COMPLICATING PROBLEM: CLIMATE CHANGE

- UNDP report 2007/2008: *"Fighting climate change: Human solidarity in a divided world"*
- Climate change takes disastrous forms in many countries: drought, floods, hurricanes etc.
- Direct damages (loss of lives, buildings), indirect damages (economy, social disruption, gender issues etc.)
- Since 1900 (*www.emdat.be, 2011*)
  - 18000 disasters reported
  - 6 billion people affected

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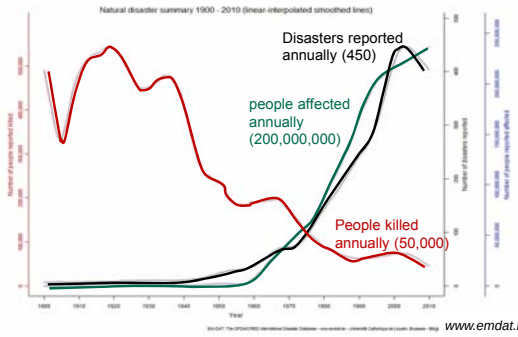
SUMMARY STATISTICS (UNTIL 2010)



www.emdat.be

INCREASE IN NUMBER DISASTERS

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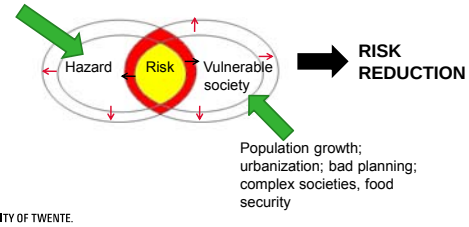
CLIMATE CHANGE INCREASES RISK AND VULNERABILITIES

Climatic Change:
Temperature rise, sea level rise and more extreme events in the field of hydro-meteorologic disasters



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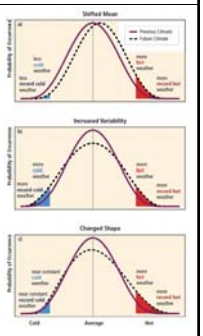
EXTREMES AND CLIMATE CHANGE

- Extremes are at the tail end of a probability distribution curve
- Different ways to describe an extreme e.g. as a threshold, or return period
- We know that the global temperature is rising – how will this affect the extremes?



Changes in Distribution - IPCC, 2011

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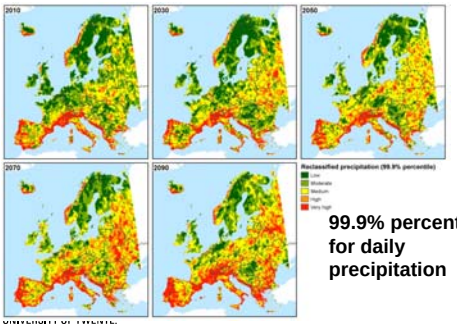
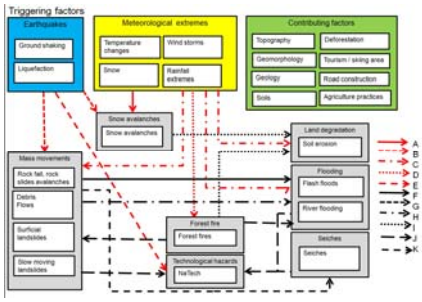
SAFELAND - CLIMATE SCENARIOS



99.9% percentile for daily precipitation

MULTI-HAZARD RISK ASSESSMENT



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MARIE CURIE PROJECT: CHANGES - INTEGRATED RISK MANAGEMENT

CHANGES stands for: Changing Hydro-meteorological risks – as Analyzed by a New Generation of European Scientists

To develop an advanced understanding of

- how global changes will affect the temporal and spatial patterns of hydro-meteorological hazards and associated risks in Europe,
- how these changes can be assessed and modeled
- how these can be incorporates in sustainable risk management strategies, focusing on spatial planning, emergency preparedness and risk communication

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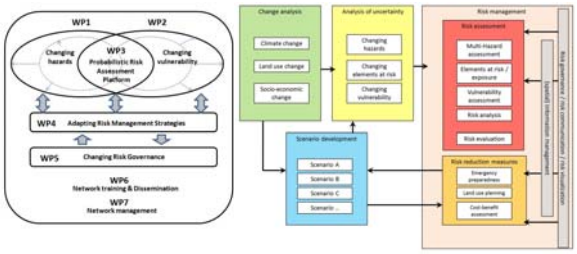
FRAMEWORK CHANGES-PROJECT



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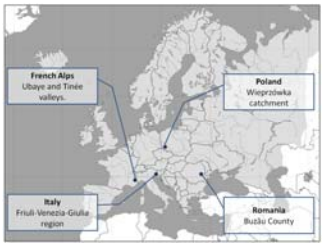
PILOT AREAS



- The project is not about study areas but about methodologies and tools
- ESRs should develop methods and apply them into at least two areas
- Interaction between ESRs is very important.
- Medium to small scales
- Open source methods
- ESR should be have appropriate disciplinary background & GIS experience

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OBJECTIVES

- Analysis of historical hydro-meteorological extreme events based on observations, satellite and re-analysis data to get better understanding of correlation between weather and hazards
- Analysis of expected climate changes in triggering conditions and extreme weather events
- Downscale climate change projections with focus on extreme weather events
- Investigate uncertainty estimation in these projected changes
- Analyze effect of projected changes in hydrological and land slide models (in collaboration with ESR02 and ESR03)

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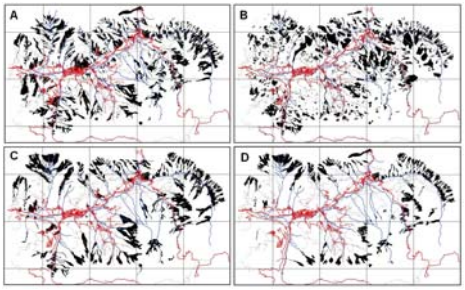
HAZARD MODELING:MASS MOVEMENTS

DEBRIS FLOWS,LANDSLIDES,ROCKFALL,SNOW AVALANCHES



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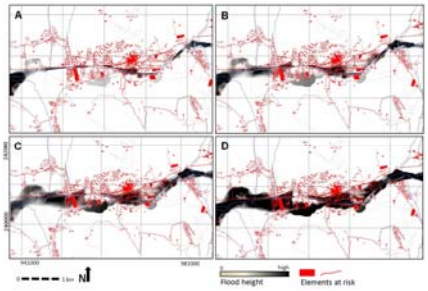
HAZARD MODELLING: FLOODS



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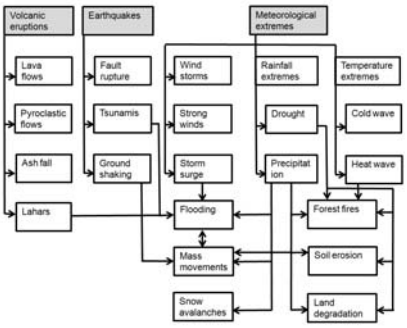
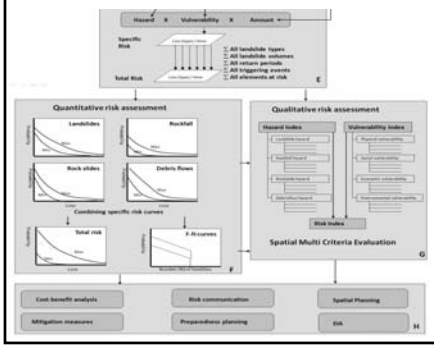
HAZARDS OCCUR IN CHAINS



RISK ASSESSMENT

EXAMPLE LANDSLIDES



E: total risk

Risk assessment

- F: Quantitative
- G: Qualitative

H: Risk evaluation

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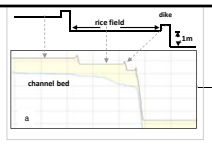
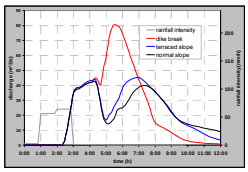
The conceptualisation of Rice field as a series pools





During a hurricane many small breakthroughs causing a cascade effect

Identify weak spots

Find strategic places to store water and strengthen dikes

Store water *before* it reaches Yen Bai

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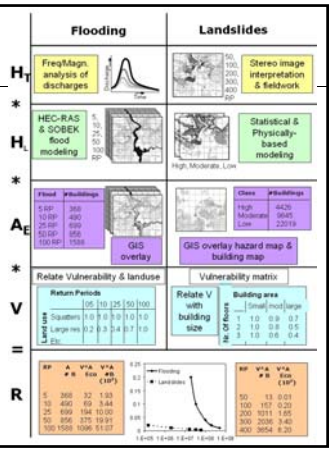
RISK ASSESSMENT

- Overview of entire process for flooding & landslides
- Individual GIS operations for each step
- Resulting in risk curves
- Same scheme for meteorological hazards
- Feedback if any condition changes



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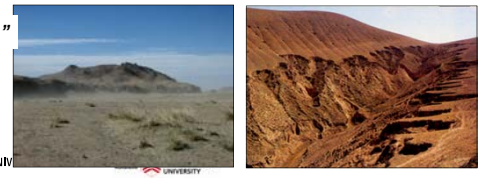
Planning problems...

...Serious disruptions...

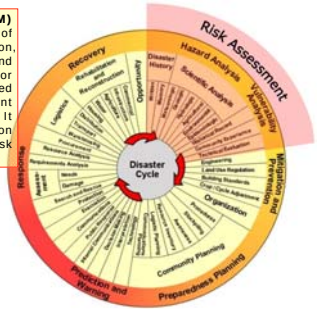
"Rapid"

"Slow"



DISASTER RISK MANAGEMENT

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



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FRAMEWORK OF RISK ASSESSMENT

RISK = HAZARD * VULNERABILITY * AMOUNT

Hazard = Probability of event with a certain magnitude

- **Spatial probability**: probability of a hazard event with a certain intensity happening at a particular location (e.g. pixel)
- **Temporal probability**: probability that an event with a certain intensity happens within a given period of time.
- **Magnitude probability**: probability that an event happening has a certain magnitude/intensity

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FRAMEWORK OF RISK ASSESSMENT

RISK = HAZARD * VULNERABILITY * AMOUNT

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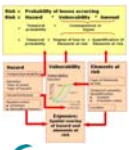

Hazard Characteristic	Definition
Magnitude	Only those occurrences that exceed some common level of magnitude are extreme.
Frequency	How often an event of a given magnitude may be expected to occur in the long-run average.
Duration	The length of time over which a hazardous event persists, the onset to peak period.
Areal Extent	The space covered by the hazardous event.
Speed of Onset	The length of time between the first appearance of an event and its peak.
Spatial Dispersion	The pattern of distribution over the space in which its impacts can occur.
Temporal Spacing	The sequencing of events, ranging along a continuum from random to periodic.

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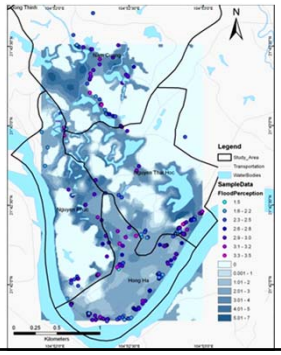
FLOOD RECONSTRUCTION: WATER LEVEL, TIMING, DAMAGE



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OBJECTIVES CHANGES PROJECT

1. Provide high-level training, teaching and research in the field of hazard and risk management in a changing environment context
2. Reduce fragmentation of research on natural processes
3. To develop an innovative methodological framework combined with modeling tools for probabilistic multi-hazard risk assessment taking into account changes in hazard scenarios and exposed elements at risk and for increasing risk awareness

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