RISK ASSESSMENT OF HYDRO-METEOROLOGICAL HAZARDS IN A CHANGING CLIMATE (CHANGES)

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Framework of multi-hazard risk assessment

Examples:
- Catchment Barcelonnette, France
- Catchment Naga city, the Philippines
- River Rhine, the Netherlands

Introduction to new project CHANGES
INCREASE IN NUMBER DISASTERS

INTRODUCTION

Much of the increase in the number of hazardous events reported is probably due to significant improvements in information access, and also to population growth, but the number of floods and cyclones reported is still rising compared to earthquakes. Is global warming affecting the frequency of natural hazards?
CLIMATE CHANGE INCREASES RISK AND VULNERABILITIES

INTRODUCTION

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

RISK REDUCTION

Population growth; urbanization; bad planning; complex societies
WHAT IS RISK?

INTRODUCTION

- 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 FRAMEWORK

**Example Landslides**

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

**RISK ASSESSMENT FRAMEWORK**

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RISK ASSESSMENT

EXAMPLE LANDSLIDES

- E: total risk
- Risk assessment
  - F: Quantitative
  - G: Qualitative
- H: Risk evaluation
RISK ASSESSMENT
SPATIAL AND MULTI-DISCIPLINARY

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


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ENVIRONMENTAL FACTORS IMPACTING ON SUSCEPTIBILITY
SPATIAL AND MULTI-DISCIPLINARY

Slope classes  Aspect classes  Lithology  Distance from river

Dem  Landuse  Soil depth

Susceptibility map  Total weight

Weight maps
BASIC DATA SETS: ENVIRONMENTAL FACTORS

Barcelonnette

Geomorphology

Land use

Orography

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FROM SUSCEPTIBILITY MAP TO SOURCE AREAS
BARCELONNETTE

<table>
<thead>
<tr>
<th>Susceptibility level</th>
<th>Hazard triggering event: source zones</th>
<th>Minor event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Major event</td>
<td>Moderate event</td>
</tr>
<tr>
<td>High</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Low</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

This means that a major triggering event might produce mass movements in the areas designated as High, Moderate and Low susceptible. Small triggering events will only trigger mass movements in the Highly susceptible zones.
HAZARD ASSESSMENT: RUNOUT MAPS

BARCELONNETTE

- Run different scenarios (major, moderate, minor events)
- Initiation areas using the output of the source area maps.
- Runout model calculates:
  - Extend of the runout
  - Kinetic energy converted to impact pressure
FLOOD HAZARD ASSESSMENT
BARCELONNETTE

- Flood modeling using 1D-2D hydrodynamic model.
- Input data:
  - DEM (!!)
  - Surface roughness
  - (include buildings)
  - Discharge (return periods)
  - Boundary conditions

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BASIC DATA: ELEMENTS AT RISK
BARCELONNETTE

Buildings

Land use

Infrastructure

Community boundaries
RISK MAP
BARCELONNETTE

**Figure 6.1: Total elements at risk**

- **Land use**
  - Residential areas
  - Commercial areas
  - Industrial areas
  - Schools
  - Hospitals
  - Medical centers
  - Nursing homes
  - Pensions
  - Petrol stations
  - Fountains
  - Roads
  - Urban areas
  - Water courses
  - Marshes and water bodies
  - Alluvial deposits

- **Elements at Risk**
  - Administration
  - Administrative zones
  - Agricultural
  - Buildings
  - Canals
  - Cellars
  - Communal areas
  - Educational
  - Parcels
  - Parks
  - Ponds
  - Hospitals
  - Medical centers
  - Nursing homes
  - Pensions
  - Petrol stations
  - Fountains
  - Roads
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RISK ASSESSMENT
BARCELONNETTE

1. Graph showing damage rate vs. inundation depth for different land uses.
2. Graph expressing the annual risk for different flood events.

Risk curve indicating return period and damage in million euros.
CHANGE IN ENVIRONMENTAL FACTORS
NAGA CITY, THE PHILIPPINES

Flash Floods

Area to be developed

Alluvial Floods

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FLOOD PROPAGATION WITH SOBEK(1D-2D)
NAGA CITY, THE PHILIPPINES
CONSEQUENCES ON 10-YEAR FLOOD CHARACTERISTICS
NAGA CITY, THE PHILIPPINES

Increase in water depth after development
+ 0.75 m
- 1.20 m

Increase in flow velocity after development
+ 1.25 m/s
- 1.15 m/s

Slum Area
UNCERTAINTY IN BASIC DATASET: LAND USE

Rhine River, The Netherlands

Different realizations of the same ecotope map based on the error matrix:
- 69% ecotope group level
- 67% vegetation type level
- 37% ecotope level

Validation disputed.
HYDRODYNAMIC EFFECTS
Rhine River, The Netherlands

Realization of floodplain roughness
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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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.
OBJECTIVES

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
WORK PACKAGES

CHANGES PROJECT

WP1: Modeling changes in hydro-meteorological multi-hazards
WP2: Evaluating changes in exposed elements at risk and their vulnerability
WP3: Development of a probabilistic risk assessment platform
WP4: Adapting risk management strategies to future changes
WP5: Establishing the risk governance framework
WP6: Network coordination and training (leader: ITC, Cees van Westen)
FRAMEWORK
CHANGES PROJECT

WP1
Changing hazards

WP2
Changing vulnerability

WP3
Probabilistic Risk Assessment Platform

WP4
Adapting Risk Management Strategies

WP5
Changing Risk Governance

WP6
Network training & Dissemination

WP7
Network management

Change analysis
- Climate change
- Land use change
- Socio-economic change

Analysis of uncertainty
- Changing hazards
- Changing elements at risk
- Changing vulnerability

Scenario development
- Scenario A
- Scenario B
- Scenario C
- Scenario ...

Risk management
- Risk assessment
  - Multi-Hazard assessment
  - Elements at risk / exposure
  - Vulnerability assessment
  - Risk analysis
  - Risk evaluation

Risk reduction measures
- Emergency preparedness
- Land use planning
- Cost-benefit assessment

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### LINK WITH ESR / ER POSITIONS

**CHANGES PROJECT**

| ESR-01 | Translation of the results of climate change models to expected changes in triggering conditions of hydro-meteorological hazards |
| ESR-02 | Development and application of probabilistic models for flood hazard assessment at regional and local scales. |
| ESR-03 | Development and application of probabilistic models for mass movement hazard assessment at regional and local scales. |
| ESR-04 | Analysis of expected changes in ecosystems and land use patterns in relation to climate change and future economic development. |
| ESR-05 | Expressing uncertainties in vulnerability and value of infrastructure, buildings and land use to hydro-meteorological hazards |
| ESR-06 | Design of a tool for probabilistic risk assessment of hydro-meteorological hazards |
| ESR-07 | Development of a method for constructing risk scenarios and risk maps with associated uncertainties |
| ESR-08 | Use of risk information in Strategic Environmental Assessment and spatial planning |
| ESR-09 | Development of an internet-based Decision Support System for the use of risk information in risk reduction |
| ESR-10 | Emergency preparedness and early warning scenarios based on the outcomes of the probabilistic risk assessment |
| ESR-11 | Comparing risk governance strategies for different EU countries. |
| ESR-12 | Risk communication with a focus on risk visualisation tools. |

**Diagram:**

- **ESR01**: Change analysis
- **ESR02**: Floods
- **ESR03**: Landslides
- **ESR04**: Changing climate
- **ESR05**: Changing hazards
- **ESR06**: Elements at risk / exposure
- **ER02**: Risk communication
- **ER07**: Risk evaluation
- **ER08**: Cost-benefit assessment
- **ER09**: Risk management
PARTNERS AND EXCHANGES
CHANGES PROJECT

Partners:
- ITC (NL)
- CNRS (FR)
- UNIVIE (AT)
- UNIL (CH)
- CNR (IT)
- PLUS (AT)
- TUDO (DE)
- TUD (NL)
- IGRAC (RO)
- IRM (PL)
- IIASA (AT)

Associated partners:
- Risques & Developpement, (FR)
- Geomer Gmbh (DE)
- Alert Solutions (NL)
- Estudios de Riesgos Naturales (ES)
- Climate Change Risk Management (UK)
- Protezione Civile of Regione Friuli-Venezia-Giulia (IT)
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.
PRACTICALITIES

Starting date: January first

Kick-off meeting: 13-14 January at ITC, Enschede, NL. All (associated) partners should be represented & advisory committee

Project duration: 4 years

Website coming soon