



Multi-hazard risk assessment

Distance education course

Guide book

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www.itc.nl/unu/dgim

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Introduction

The world is confronted with a rapidly growing impact of disasters, due to many factors that cause an increase in the vulnerability of society combined with an increase in (hydrometeorological) hazard events related to climatic change. The possible impacts of hazardous events are large, especially in developing countries and governments have to incorporate risk reduction strategies in development planning at different levels. The evaluation of the expected losses due to hazardous events requires a spatial analysis, as all components of a risk assessment differ in space and time. Therefore risk assessment can only be

carried out effectively when it is based on extensive, multidisciplinary studies on the basis of spatial information, derived from Remote Sensing and other sources. There is an urgent need to include the concepts of disaster geo-information management into emergency preparedness planning, spatial planning and environmental impact assessment. This requires capacity building and training of disaster management experts and professionals, such as planners, engineers, architects, geographers, environmental specialists, university teachers etc. The Hyogo framework of action 2005-2015 of the UN-ISDR indicates risk assessment and education as two of the key areas for the development of action in the coming years.

A number of organizations are specialized in providing short training courses on disaster risk management related issues. Some organizations have also prepared training materials that are accessible through the internet (see examples in box left). Most of these however are concentrating on community-based methods. Disaster risk management courses at BSc or MSc level are now available in many Universities in all continents.

Relatively few training materials are available on multi-hazard risk assessment. Good textbooks on the subject are still not available. Online training materials can be obtained for example from the websites of FEMA and EMA. The development of innovative forms of learning and teaching oriented towards building new curricula in the field of natural risk has attracted attention in European initiatives such as DEBRIS and NAHRIS.

As far as GIS-related material related to multi-hazard risk assessment is concerned, the HAZUS methodology developed in the US can be considered the standard. This comprehensive loss estimation software which runs under ARCGIS is a very good tool for carrying out loss estimations for earthquakes, flooding and windstorms (FEMA), but is restricted to use in the USA, due to constraints in the data and the classifications used for elements at risk and fragility curves. The manuals of Hazus, however, provide a very good overview of the entire process of multi-hazard risk assessment. Courses on the use of HAZUS can be followed online from the ESRI Virtual Campus. However, complete GIS based training packages on spatial hazard and risk assessment using low-cost or free GIS software are still very scarce, to the knowledge of the author. One example is a training package in English and Spanish developed for Central America in the framework of the UNESCO RAPCA project (ITC).

Hyogo framework for action 2005-2015.

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

:
<http://www.unisdr.org/eng/hfa/hfa.htm>



Some organizations that offer training courses on Geoinformation for Disaster Risk Management

Asian Disaster Preparedness Center

<http://www.adpc.net>

Provention consortium

<http://www.proventionconsortium.org/>

Worldbank on-line courses

<http://go.worldbank.org/RUY76WGO1>

Pacific Disaster Center

<http://www.pdc.org/web/pdchome.html>

ESRI

<http://training.esri.com/Courses/>

FEMA

http://www.fema.gov/plan/mitplanning/planning_resources.shtm

UNU ESD

<http://www.unu.edu/esd/>

ITC UNU-ITC DGIM

<http://www.itc.nl/unu/dgim/>

IIRS, India

<http://www.iirs-nrsa.gov.in/>

UGM, Indonesia

<http://geo.ugm.ac.id/en/>

AIT-GIC, Thailand

<http://www.geoinfo.ait.ac.th/>

CIGA, UNAM, Mexico

<http://www.ciga.unam.mx/>

CLAS, Bolivia

<http://www.clas.umss.edu.bo/>

This course intends to fill this gap and provide you with practical hands-on experience on how you can use spatial information for hazard, vulnerability and risk assessment.

Objectives

This course deals with the procedures to collect, analyse and evaluate spatial information for risk assessment from natural and human-induced hazards (such as geological hazards, hydrometeorological hazards, environmental hazards and technological hazards). The course will guide you through the entire process of risk assessment, on the basis of a case study of a city exposed to multiple hazards, in a developing country (RiskCity).

At the end of this course you will be able to:

1. understand the concepts of hazard assessment, elements at risk mapping, vulnerability assessment, and risk assessment;
2. formulate the spatial data requirements for risk assessment;
3. generate an elements at risk data base using GIS;
4. formulate the requirements of hazard data and methods;
5. apply various methods for vulnerability assessment;
6. generate risk maps using qualitative and quantitative methods;
7. have insight in how a risk assessment could be carried out in your own situation;

This course is designed for all those who have to carry out risk assessment and need knowledge and skills on the procedures to do that using a GIS. These include professionals working in NGOs and governmental organisations related with disaster risk management, but also professionals, planners, engineers, architects, geographers, environmental specialists, university teachers. Some basic background in Geographic Information Systems is desirable, although not strictly required, as the course follows a step-by-step approach which allows participants to rapidly acquire the basic skills in handling GIS software. If you lack the basic GIS skills it might be better to follow the course in a classroom environment, where more direct support on the software can be given. Courses on multi-hazard risk assessment are offered annually in the Netherlands, Mexico, Bolivia, and Thailand, and frequently also in India and China.

Partner organizations involved in the development of this package:



<http://www.itc.nl/unu/dgim/>



<http://www.geohp.com/lab>

<http://www.adpc.net>



<http://www.geoinfo.ait.ac.th/>

<http://www.clas.umss.edu.bo/>

<http://www.ciga.unam.mx/>

Course structure

The course is composed of a number of sessions. Below is a summary of the sessions and detailed content.

Session 0: Getting started

Theory: Introduction to the course, objectives, structure, and set-up. Explanation of the available materials.

Activities: Set up Blackboard account, install ILWIS software, getting to know the tutors and fellow students.

Session 1: Introduction to disaster risk management

Theory: Introduction to disaster risk management and risk assessment.

Exercise: Generation of a hazard profile using disaster databases; Introduction to ILWIS, and introduction to the RiskCity dataset. Learn the various hazard problems by evaluating high resolution images

Session 2: Obtaining spatial data for risk assessment

Theory: Presentation of data requirements for the various types of hazards. Sources of spatial data.

Exercises: Defining spatial data requirements for risk assessment; Internet search for information on risk assessment; acquiring free and low cost data; generating three dimensional image data using Google Earth; stereo image interpretation

Session 3: Hazard Assessment

Theory: Hazard types; Main concepts of hazard assessment; Frequency magnitude – relationships

Exercises: Frequency assessment; Selection of hazard assessment example (flooding, landslides, earthquakes, technological hazards, volcanic hazards etc)

Session 4: Elements at risk assessment

Theory: Types of elements at risk; classification of buildings, infrastructure, lifelines, critical facilities; population information; collection of elements at risk information.

Exercise: Generating an elements at risk database from scratch; Generating an elements at risk database using available data (building footprint map, census data and LiDAR) ; Participatory GIS

Session 5: Vulnerability assessment

Theory: Types of vulnerability; social vulnerability; physical vulnerability; methods for vulnerability assessment; participatory GIS; Spatial Multi Criteria Evaluation

Exercises: Defining vulnerability curves; Spatial Multi-criteria evaluation for vulnerability assessment

Session 6: Risk estimation

Theory: Loss estimation models; HAZUS; qualitative risk assessment; QRA; basics of flood risk, seismic risk, landslide and technological risk assessment;

Exercises: Creating risk curves; Selection of risk assessment method: flooding, earthquakes, landslides, technological. Multi-hazard risk assessment

Session 7: Risk management

Theory: Risk evaluation; risk governance; risk communication; cost benefit analysis; Using risk information for emergency planning; spatial planning, and Environmental Impact Assessment

Exercises Use risk information for disaster preparedness; Cost benefit analysis

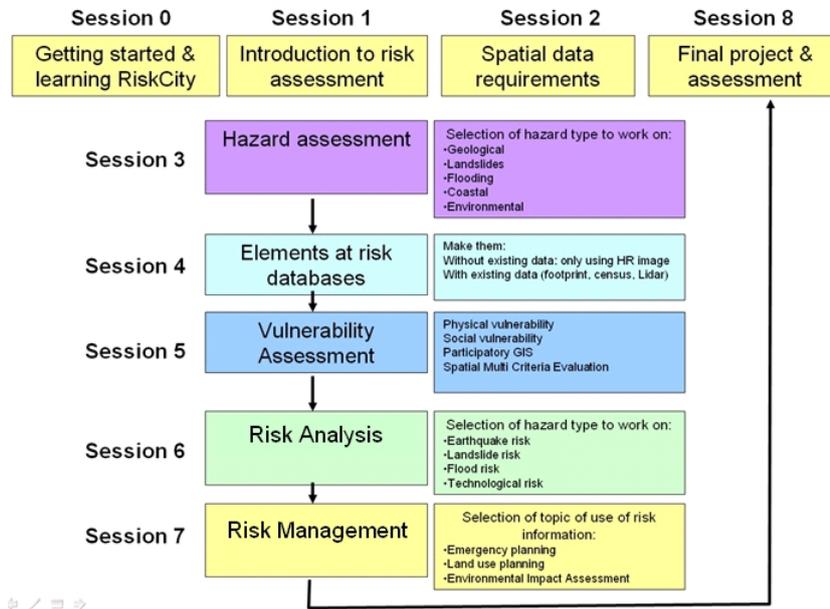
Session 8: Final project and examination

Discussion: How to do such a study in your area?

Final project: Selection of project topic related to risk assessment and its use in risk management

Examination: multiple choice exam.

The figure below illustrates the course structure:



The table below gives an overview of the sessions 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
	Choice landslides	Exercise 3F2: Flood hazard monitoring using multi-temporal SPOT-XS imagery
		Exercise 3L1. Landslide susceptibility assessment using statistical method
	Choice: Volcanics	Exercise 3L2. Deterministic landslide hazard assessment
	Choice: Earthquakes	Exercise 3V: Modeling erosion from pyroclastic flow deposits on Mount Pinatubo
	Choice: Coastal	Exercise 3E: Earthquake hazard assessment
		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 vulnerability 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
		Select a topic from a list and carry out your own analysis
8. Final project		

Software

The course uses standard software like Adobe Acrobat Reader ([Click here](#) to download it if you don't have it yet)

The course is based on the use of Open-Source software. Open Source software has a number of criteria (<http://www.opensource.org/docs/definition.php>), some of which are:

- Freely distributed, downloadable from the Internet
- Access to the source code of the software
- Allows modifications or additions to the programme
- No discrimination against persons

ILWIS



The main software that will be used for all the GIS exercises that are part of this course written for the ILWIS software. ILWIS is an acronym for the Integrated Land and Water Information System. It is a Geographic Information System (GIS) with image processing capabilities. ILWIS has been developed by the International Institute for Geoinformation Science and Earth Observation (ITC), Enschede, The Netherlands.

ILWIS is a remote sensing and GIS software which integrates image, vector and thematic data in one unique and powerful package on the desktop. ILWIS delivers a wide range of features including import/export, digitizing, editing, analysis and display of data, as well as production of quality maps. ILWIS software is renowned for its functionality, and user-friendliness, and has established a wide user community over the years of its development. Even after its last commercial release in 2005, its user community has remained active, both within and outside ITC.

ILWIS is an open source software, and can be downloaded from the following web-site: <http://52north.org/ilwis>

ILWIS 3.4 Open is included on your course DVD in the ...Software\ILWIS 3.4 Open\ folder.

To install the software, run the ILWIS34setup.exe program.

In the Software\ILWIS 3.4 Open\User's Guide folder you will find the ILWIS 3.0 Academic User's Guide in PDF format.

Installation of supporting software

The following tools are available on your CD-ROM:

- Acrobat Reader: to open PDF files. Many files of the course material are in PDF format.
- MediaPlayer: used for Video-lectures and other multimedia.
- Flash Player: used to open the animations attached to the e-lectures
- ShockWave-PlugIn: used for playing video animations related to web sites.

! Some functions of the e-lectures need Microsoft Internet Explorer. Please make it sure that you use this browser as the default when running the e-lectures.

Acknowledgements



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Anneke Nikijuluw has been very helpful in assisting us with the organisation of course and arrangement of course materials. Linlin Pei helped us in making the demonstrations for ILWIS. Cecille Plomp made the introduction movie. Ineke ten Dam gave us useful advice on the development of the materials. Job Duim and Benno Masselink helped in making a number of illustrations. Sabine Maresch provided a lot of project support in using the training materials in various courses.

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We would like to thank the following persons for their permission to use certain parts of the materials:

Session 1: N.M.S.I. Arembepola, Falak Nawaz, Simone Frigerio
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 Session 5: Luc Boerboom, Juan-Carlos Villagran de Leon, Jorn Birkmann,
 Session 6: Thomas Glade, Enrique Castellanos,
 Session 7: Barend Köbben, Rob Lemmens, Emile Dopheide, Joan Looijen, Amod Dixit, N.M.S.I. Arembepola, Falak Nawaz
 RiskCity exercises : Manolo Barillas, Graciela Peters Guarin
 This work is part of the United Nations University – ITC School for Disaster GeoInformation Management (www.itc.nl/unu/dgim)

Disclaimer:

This book is still a draft version. It still has to go through a reviewing phase, so there may be quite some mistakes in it. We would appreciate it if you could report any mistakes to us. This can be done by sending an e-mail to westen@itc.nl, in which you indicate the page number and the problem.

In this book we have tried our best to indicate the sources of information. If you feel that we have omitted to indicate the source properly, please inform us.

Structure of the training materials

The training materials consist of:

A guide book,

consisting of 8 chapters and an introduction, following the same structure as the sessions explained above. The guide book will contain for each session:

- **Theoretical background**, which guide you through the session and which contain theoretical parts, highlighting the main theoretical aspects, mixed with short assignments and questions, and links to relevant internet sites.
- **Tasks**: mixed with the theory of the guide book you will find a number of tasks where you are asked to carry out certain small assignments, which will make you understand the theory better, and apply it to your own situation. The answers to the tasks don't have to be submitted for the course. The answers will be made available on blackboard. You can also use the discussion board in Blackboard to discuss the answers with other participants and teaching staff.
- **Selftests**: each session has a selftest. Answers are available through Blackboard.
- **Further reading**

A RiskCity exercise book

RiskCity exercise descriptions. The exercises are written in such a way that whenever students have to carry out an action with GIS this is written in a light green box. Normally the exercise instructions are given completely (so-called "cook book style") so that it is easier to carry out the instructions also for people with no experience in ILWIS. There are also additional optional exercises which require more knowledge on the software, and which are indicated as "Optional exercise for experienced ILWIS users". These instructions are not in "cook book style", and require more knowledge on how to solve a particular problem with ILWIS. Non experienced ILWIS users might like to skip these exercises in the beginning.

A DVD



The course DVD contains the following materials:

- An introduction video for the course.
- The ILWIS software with its users guide.
- Some other generic software needed to follow the course (Acrobar reader etc.)
- The Guide Book chapters as PDF files
- The RiskCity exercise descriptions as PDF files.
- The data for the RiskCity exercises.
- Demonstration videos explaining part of the RiskCity exercises.

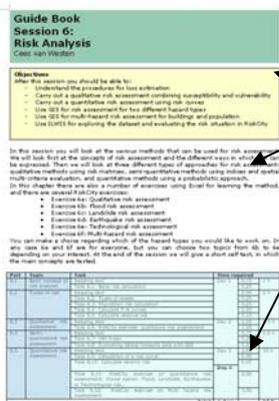
Digital datasets of RiskCity for each exercise. Each exercise has its own data, which are stored in a separate subdirectory. Results from one exercise that are needed for the next, are provided in the dataset of the next exercise, so you start each exercise with a "clean slate"

Blackboard (bb.itc.nl)

The course has also an internet site with educational support software (Blackboard), which can be reached through: bb.itc.nl It containing all materials and the tools for communication, and uploading of results

- All Guide book chapters, and RiskCity exercises as PDF files
- The answers to the selftests of the Guide Book
- Answer sheets for the RiskCity exercises
- Discussion board for the answers of the tasks.

How to use the Guide Book



The Guide Book contains 8 sessions. Each session starts with:

- The objectives of the session
- A description of the contents of the session
- A table with an overview of the sessions, its different sections and the tasks within each section. Also for each section and task the time required is indicated. Also the total time needed for the session is indicated in number of days, assuming that on average you will spend 4 hours a day on the course.

The Guide book contains different types of information. They are indicated in different colours.

Definitions and equations are always presented in such boxes with yellow color and red outline.

Task 1.1: Question (duration 5 minutes)

Each session contains a number of tasks that are related to the theory. Tasks are always indicated in these green boxes. For each task the time required is indicated. Each task is numbered. The task will be discussed on the Blackboard where you can discuss the answers with the other participants and with the staff.

Task 1.10: RiskCity exercise (duration 1 hour)

If the task refers to a RiskCity GIS exercise it is indicated in such types of boxes. In this case you have to look for the RiskCity exercise in the exercise book, and follow the instructions there. Once you finish the exercise, you proceed in the Guide Book. The answers to the exercise are available in Blackboard as answer sheets.

The Guide Book is the main source for the course. It is your guide and it indicates which tasks and GIS exercises should be done when. It also has a number of choices. These are particularly in session 3 on Hazard Assessment, where you can choose after session 3.3 one of the following topics (linked to sections of the guide book and separate Riskcity exercises):

- Landslide hazard
- Flood hazard
- Earthquake hazard
- Volcanic hazard
- Coastal hazards.

Also in session 4 there are two choices to make a RiskCity exercise: "Generation of an elements at risk database from scratch", or "Generation of elements at risk database using existing data".

Finally also in session 6 (Risk Analysis) you can make a selection to do a quantitative risk assessment either for flooding, landslides, earthquakes or technological hazards.

Each session of the Guide Book ends with a selftest (you can find the answers on Blackboard) and literature references.

How to use the RiskCity exercise descriptions

The exercise descriptions contain different parts.

Information

Information written in normal text without colours are related to the explanation on the various procedures used throughout the manual.

ILWIS instructions

The exercises are written in such a way that whenever you have to carry out an action with GIS this is written in a light green box. Normally the exercise instructions are given completely (so-called "cook book style") so that it is easier to carry out the instructions also for people with no experience in ILWIS.



- This is an example of a box containing the actual instructions on using the ILWIS software

Additional information

This is a textbox that contains additional information, e.g. on the specific aspects of the software or the GIS operations that are carried out. They sometimes refer also to the ILWIS Help or to other links

This is a an example of such a text box

ILWIS instructions for advanced users.



- This is an example of a box containing instruction for advanced users

There are also additional exercises which require more knowledge on the software, and which are indicated as "Optional exercise for experienced ILWIS users". These instructions are not in "cook book style", and require more knowledge on how to solve a particular problem with ILWIS. If you are not an experienced ILWIS user you might like to skip these exercises in the beginning.

Answers

In many cases you are asked to provide the answer to a specific problem, and write these down in a table, indicated in Blue colour. These are also the answers that you should submit in the small report for uploading to the Blackboard after completing the exercise.

Below is an example of such an answer table.

Which signs can you see of a recent disaster in the area?	X	Y



**Watch Demo 1
for
instructions**

Demos

In the first RiskCity exercises you can also find demonstrations, which are explaining steps that you need to do in ILWIS and that need a certain amount of user interaction, which is more difficult to explain in the text. You can find the demo files in : \RiskCity_exercises\Demos_RiskCity

Answer sheets

We have made an answer sheet for each exercise. This will help you in checking the results of your work. **The answersheets can be found in Blackboard.** The answer sheets contains:

- The answers of the questions that are asked in the text.
- Screen shots of main result maps that have to be produced as part of the exercise, together with some additional explanation
- The procedure and answers of the Optional exercises for advanced ILWIS users.

Exercise data

The GIS data for the exercises has been prepared carefully, in order to avoid confusion during your work.

IMPORTANT:

- Each exercise has its own data, which are stored in a separate subdirectory. Results from one exercise that are needed for the next, are provided in the dataset of the next exercise, so you start each exercise with a "clean slate"
- Copy the exercise data in the same directory structure to your harddisk
- Work in the same subdirectory with the data for the specific exercise
- Do not copy the data from one directory to the other.

