Exam GEO4-4425 Hazards and Risk Assessment
18 April 2012

You may answer in English or Dutch as you prefer

Question 1:
Risk assessment is an important part of natural hazards studies for among others landslides, flooding, earth quakes, volcanic eruptions, carbon storage, etc. The equation used to compute risk is given by:

Risk = Hazard * Exposure * Vulnerability

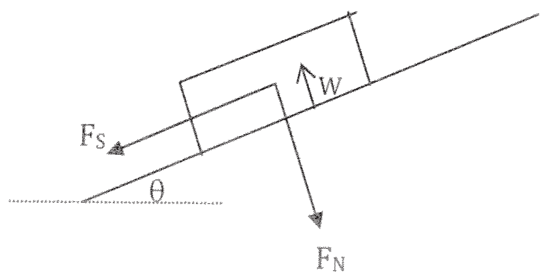
1a. Describe each of the four components of this equation.

1b. Give an example of risk assessment for one of the natural hazards discussed during the course and illustrate how the equation is used to assess risk.

Question 2:
Suppose you are asked as a consultant to study a possible unstable slope in the Meuse valley in the southern, hilly part of The Netherlands. A road is planned at the top of this slope. During a field visit you determine surface expressions of creep and land slides.

2a. Name and describe three ways in which vegetation affects slope stability.

You are using the infinite slope model to compute the safety factor F (stability) of this slope. You simplify the situation on this slope as given in the figure below.



The safety factor of a slope is computed by the following equation:

$$F = \frac{c + (\rho_s g H \cos(\theta) - \rho_w g W)\tan(\varphi)}{\rho_s g H \sin(\theta)}$$

2b. At what values of F is a slope stable, unstable and quasi stable?

2c. Compute the safety factor for the given slope assuming:
- the regolith/soil mass on the slope is 3.0 meters;
- a slope angle of 18 degrees;
- soil/regolith cohesion of 1500 N/m^2;
- regolith/soil angle of internal friction of 15 degrees;

- density of the regolith of 1900 kg/m^3;
- density of water of 1000 kg/m^3;
- unsaturated, dry conditions on the entire slope.
- acceleration due to gravity: 9.8 m/s^2;

What is the value of the safety factor? Based on your computed factor of safety, is the slope safe, yes or no?

2d. What happens if you were mistaken about the soil/regolith depth, suppose it is 6.0 m instead? What is the new value of the safety factor? Is the slope stable or unstable?

2e. Would you recommend to construct a high way on this slope in Limburg? Why?

Question 3:

3a. Hydrographs play a major role in flood studies and flood forecasting. Give a description of a hydrograph. What is given on the Y- and X axes of a hydrograph? Describe the most important properties of a hydrograph.

3b. Draw an example of a storm event hydrograph with labels on X- and Y-axis. Draw an example of an annual hydrograph of the river Rhine including X and Y axes. Motivate in a few lines the shape of your hydrographs.

3c. Consider a fully natural, forested watershed. Describe and discuss the effects on the hydrograph of a river and the risk for flooding of 3 management measures:

1. a dam construction in the watershed;
2. urbanization in the watershed;
3. a land use change from forest into agricultural use (corn).

Draw in one graph the 4 hydrographs: the initial hydrograph of the natural forested watershed and the hydrographs for each of the 3 indicated changes a, b and c.

3d. A return period (or a discharge – frequency) curve is an important tool for river authorities to assess flooding frequencies and for planning mitigation measures. Table 1 below shows the annual peak discharges of the Patrick River.

- Calculate the recurrence intervals for each of the annual flow data points
- Draw (by hand) the magnitude-frequency map for this river
- Extrapolate the discharge of a 20-year flood.

Discuss your findings.

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Table 1: Patrick River Stream Gauge Data, peak annual flow for 9 years.

Year	Discharge (m3/s)
1995	30
1996	280
1997	45
1998	28
1999	120
2000	26
2001	100
2002	23
2003	20

Question 4:

On a particular day, a flood forecasting system using ensemble weather forecasts, predicts that polder X near town Y might be flooded with a maximum waterlevel of 82m above sealevel. The flood is expected in 40 hours. 20 out of 50 ensemble forecasts predict this waterlevel of 82m. The other ensemble forecasts predict a waterlevel that is lower than the dykes that protect the polder. All weather ensembles are equally likely.

If needed, this polder can be protected by elevating the dykes with sandbags and temporary floodwalls. The total construction costs of these sandbags and floodwalls are 200.000 Euro. It takes 24 hours time to arrange and construct he dyke elevation.

The digital elevation model of the polder is given below (units in meters above sealevel):

80	79	78
81	80	78
82	81	78

The land use map of the polder is given below (URB=urban, IND=industry, AGR=agriculture):

IND	IND	AGR
URB	URB	AGR
URB	URB	AGR

The depth-damage curves of all landuse-types all have similar linear shapes, with no damage at waterlevel of 0 meters, and maximum damage at 5m waterlevel. Maximum damage per 400m2 for URBan land use is 400.000 Euro, for INDustry 250.000 Euro, and for AGRicultural land use 1000 Euro. The pixelsize of the DEM and LANDUSE map above is 20m*20m.

4a. what is the expected damage in euro if the polder gets flooded?

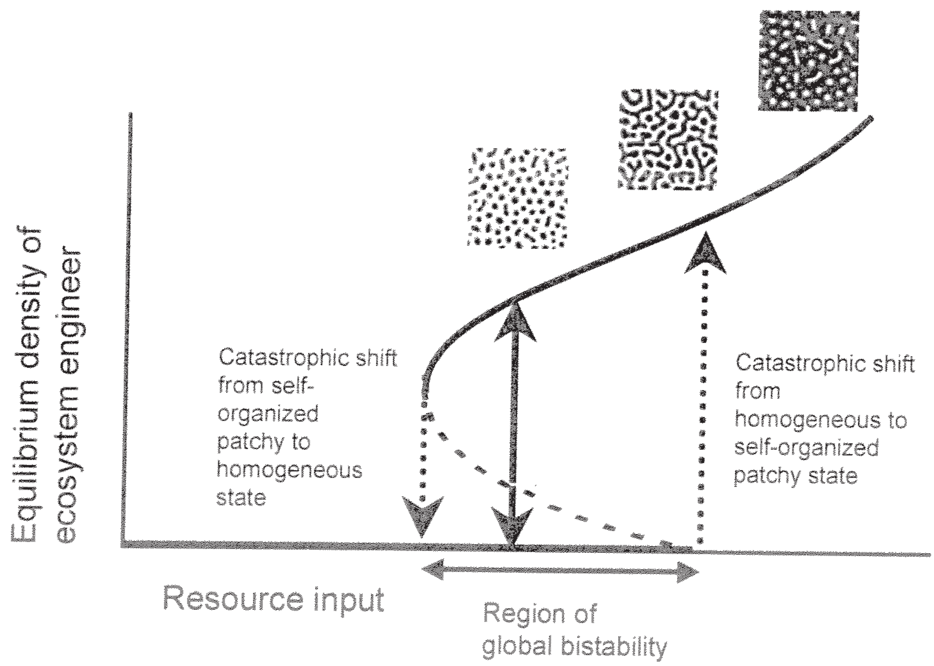
4b. what is the probability of the flooding of 82m waterlevel?

4c. if you are the forecaster-on-duty, would you issue a flood warning, such that the sandbag protection measures can be initiated. If yes, based on what objective criteria would you make the alert? If no, based on what criteria would you not make the alert?

4d. False flood alerts need to be avoided. What technical solutions do systems such as EFAS (The European Flood Awareness System) use to reduce false alerts as much as possible?

4e. Would you know what the "Cry-Wolf" expression stands for, and why this relevant is in the field of forecasting?

Question 5:
In the Rietkerk et al (2004) paper "Self-organized patchiness and catastrophic shifts in ecosystems" in Science that you studied for this exam you found the following figure:



5a. What is meant by spatial selforganization?

5b. What is meant by global bistability?

5c. What is meant by catastrophic shift?