# Resilience

## What is resilience?

*noun*

the ability of a substance or object to spring back into shape; elasticity; the capacity to recover quickly from difficulties; toughness.

"Although there is a variety definition of resilience, three common properties of resilience are dominated in resilience literature. The first property is about the **speed of recovery**. The second is the **magnitude of a disturbance relative to a threshold that can be absorbed before a system changes** its structure by changing the processes and variables that control its behaviors. The final property is about the **capacity to learn for adaptation or creativity**." Van Kien, 2011.

# Resilience and Resistance

# Resilience



Reduction of Impacts

Reduction in Time to Recover

# Resilience

1) Reduction of impacts

2) Ability and time to recover

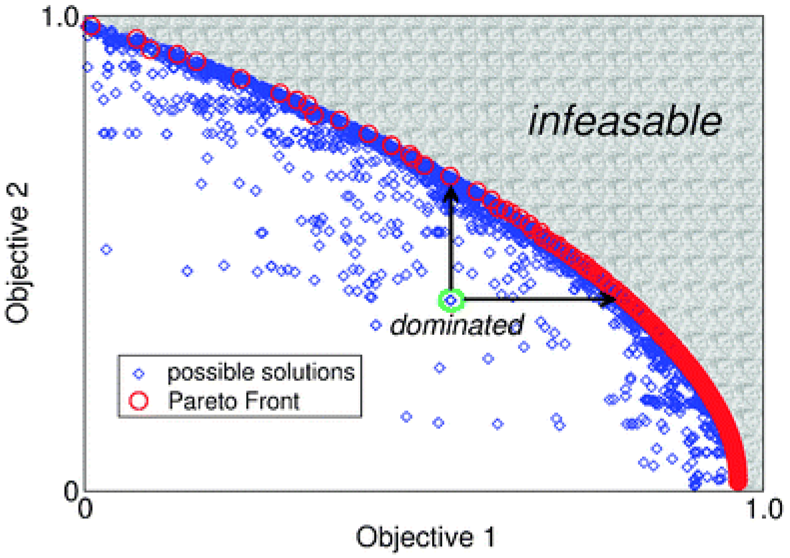
3) Capacity to learn for adaptation or creativity

# Multi-Objective Optimization

- When decision making is emphasized, the objective of solving a multi-objective optimization problem is referred to supporting a decision maker in finding the most preferred Pareto optimal solution according to his/her subjective preferences. The underlying assumption is that one solution to the problem must be identified to be implemented in practice. Here, a human **decision maker** (DM) plays an important role. The DM is expected to be an expert in the problem domain.

- Objective 1: Reduction of Impacts
  - 1a) Life
  - 1b) Property

- Objective 2: Time to Recover
  - Community
  - Housing
  - Economics
  - Transportation



# Measures of Resiliency

## Quantitative measures of resiliency

Resilience and flood risk management: a systems approach applied to lowland rivers --Karin Marianne DE BRUIJN

$$EAD = \int_{1/10000}^{P(D=0)} PD(P)dP$$

$$EANAP = \int_{1/10000}^{P(D=0)} PA(P)dP$$

$$EANC = \int_{1/10000}^{P(D=0)} PC(P)dP$$

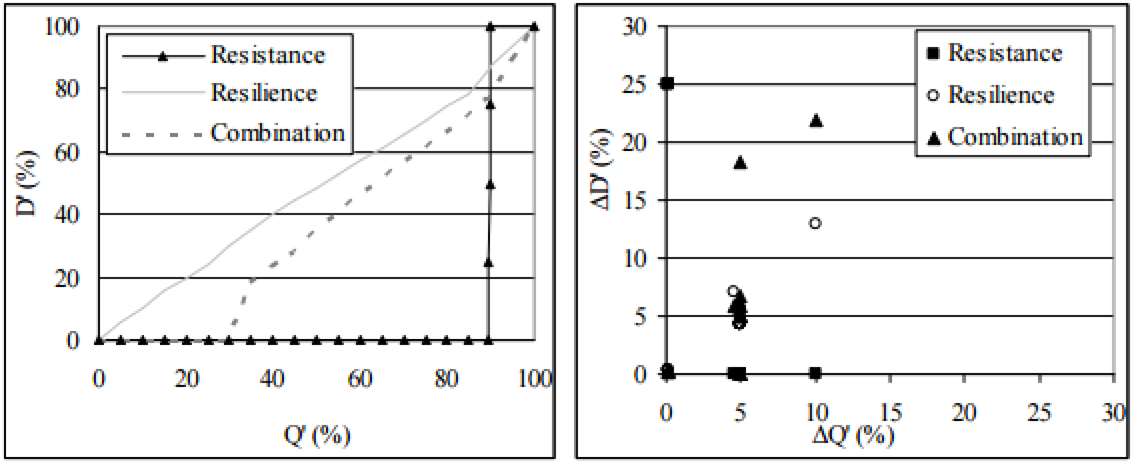



Figure 3.1 Discharge and damage increase in percentages (left) and the relative damage and discharge increase per step (right) (The graduality of the resistance curve is 0, of the resilience curve 0.91 and of the combination 0.7)

EAD = expected average damage per year ($ /year)
EANAP = expected average number of affected persons per year (number / year)
EANC = expected average number of casualties per year (number / year)
P = annual flood probability
D(P) = expected damage as function of probability ($)
A(P) = number of affected persons as function of probability (number of persons)
C(P) = number of casualties as function of probability (number of casualties)

# Measures of Resiliency

**The resilience indicator for graduality**

Four different options for the graduality indicator were studied:

1. The slope *dD/dQ* (D = damage and *Q* = discharge level);
2. The width of the discharge range in which most damage increase occurs;
3. The adapted Gini-coefficient;
4. The average difference of the increase rate of damage and discharge.

The first three are discussed in this textbox, the fourth in the main text.

*1. Slope: dD/dQ*

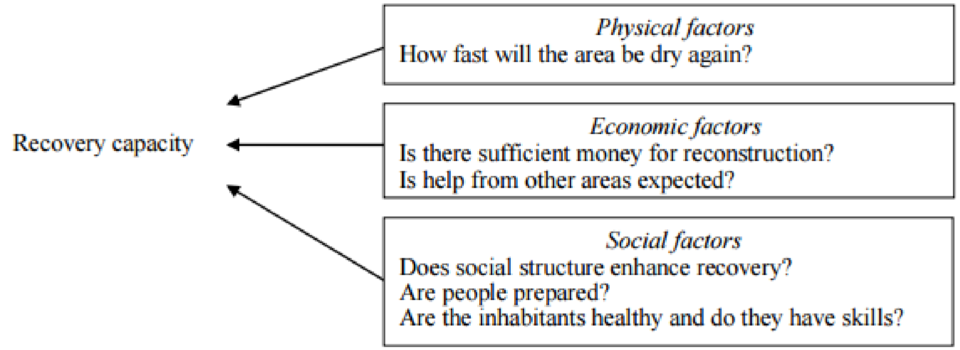
The slope *dD/dQ* is difficult to express by only one number because it is not uniform (see main text). The slope of a certain part of the curve, e.g. from T= 10 to T = 100 years could be used. However, this is a very arbitrary choice.

*2. The part of the discharge range in which most damage increase occurs*

To calculate this indicator the damage is calculated in percentages:

$$\text{Graduality} = \frac{\text{Discharge range in which 50\% of the damage increase occurs (25\% to 75\%)}}{\text{Total discharge range}}$$

The indicator is intuitively correct: The wider the discharge range in which most damage increase occurs, the more gradual the damage increase probably is. In diked systems where embankments break when they are overtopped, the value for this indicator will be very small. If damage increases gradually with discharge, the value for the indicator will be much higher. A disadvantage of the indicator is that the choice for the thresholds of 25% of the maximal damage and 75% of the maximal damage is arbitrary.



# What does this mean in the real world?

***Reduction of Impacts***

1) Property/Infrastructure

Corridor restoration, increased capacity

Removing assets from hazard zones

Properly sized infrastructure

On-site mitigation

Knowing vulnerabilities

2) Life Safety

Evacuation plans

Education

Shelter in place

# What does this mean in the real world?

***Time to Recover***

1) Availability of Community Resources during and directly after a disaster

- Local knowledge
- Local equipment
- Local materials

2) Education and Public Outreach

- What “recovery” means
- What an individual’s responsibilities are
- Coordinated volunteer efforts

3) Financial

- Insurance
- What if no federally declared disaster?
- Local funds

# What does this mean in the real world?

***Capacity for Adaptation and Creative Solutions***

1) Understanding of acceptable and unacceptable change

2) Adaptive management and scope flexibility

- 3) Knowledge sharing

# Questions?

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