Flood Risk Management in Austria

Trends and Strategies Towards an Integrated Approach

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Objectives: Review of Risk Management Approaches and Discussion of the Austrian Strategy

Organisation of the Presentation

• Introduction and Definition of Risk
• Flood Risk Management Strategies
• The River Basin Approach
• Summary and Conclusions
Definition of Flood Risk

- There is a random event $Q$
- This event has a probability of occurrence $f(Q)$
- This event has consequences (damages) $D(Q)$

- The risk is understood here as

$$
R(Q) = \int_{0}^{\infty} f(Q) \cdot D(Q) \cdot dQ
$$
Design Approaches

(1) Normative goals (like in Austria) defined by a minimum protection level

- Residential areas (100 years flood)
- Infrastructural measures (30 years flood)
- Agricultural land (no protection)
(2) Economically Based Approach

Minimise total costs:

**CC** Construction costs
**DF** Discounting Factor

\[
\text{Min}\{\text{Total Costs}\} = \text{Min}\left\{ CC(Q^X) + DF \cdot \int_{Q^X}^{\infty} f(Q) \cdot D(Q) \cdot dQ \right\}
\]
Analysis of the Two Approaches

- Error in the observations (±10 % at floods)
- Uncertainty in the probability distribution f(Q)
- Uncertainty in the damage function D(Q)
- There is also an uncertainty in the resistance R and thus there is a probability g(R)
- There is a non-stationarity in f(Q) due to seasonality, land use change and climate change
- There is an non-stationarity in damages due to land use changes
Uncertainties

Data
• During a flood rarely reliable measurements are taken
• The time series are limited to a few decades
• The sample is not necessarily representative
• Therefore, we have to consider parametric uncertainty

Statistics
• Which probability distribution is the right one?

Damage function
• Due to changing land use there is also a change in the loss function
Consideration of Resistance

• The ‘Resistance’ of a flood protection structure has an internal failure probability (dike breaks, overtopping due to land subsidence, change in cross sections due to sedimentation...)

\[
R(Q^*) = \int_{R_{\text{Min}}}^{R_{\text{Max}}} g(R) \cdot \int_{Q^*(R)}^{\infty} f(Q|R) \cdot S(Q) \cdot dQ \cdot dR
\]
Non-stationarity in $f(Q)$ and $g(R)$

How to handle non-stationarities?

- The occurrence of floods is seasonally dependent
- There is a change in flood frequency due to human intervention
- A study from Switzerland concludes that the more is invested in flood protection measures the larger are the damages

How to handle social aspects?

- Equity measures and cost allocation
Austria and Some Investigated Basins

Investigated Catchments

Basin A

Basin B

Marchfeld

Traisental

Oberes Ennstal

Gailtal

Leibnitzter Feld
Probability of Floods at a Given Day Within a Year (Intensity or $\lambda(t,Q>x)$)

Basin A: Rainfall caused floods

Basin B: Snowmelt and rain
Time Dependency in the Damage $D(t)$

Short Term Variability
- A basin attractive for summer tourism
- A basin with agricultural use

Long Term Variability
- Modified (intensified) land use
The Role of Human Intervention

- Due to land use, impoundments, dikes and reservoirs the flood frequency has been changed

- Climate change may have severe impacts in urbanised areas and in mountainous regions

- \( f(Q,t) \) and \( D(Q,t) \) have to be considered
Change in Flood Dynamics Due to Human Intervention

Flood frequency and flood dynamics has been changed by human intervention

Runtime of flood peaks from Ybbs to Vienna

1954  54 h
1965  45 h
1975  38 h
1981  32 h
1991  16 h
Changes in Land Use: Highway Construction
Consideration of Instationarity

- The risk becomes time dependent

\[
R(Q^*, T) = \int_{T_{\text{start}}}^{T_{\text{end}}} DF(t) \cdot \int_{Q^*}^{\infty} f(Q|t) \cdot S(Q|t) \cdot dQ \cdot dt
\]

- Any optimisation would require the knowledge about future trends in \( f(Q,t) \) and \( D(Q,t) \)
Flood Control Strategies in Austria

- In the last 100 years there was a change in Austria from linear measures to dikes, levees, reduce the discharge capacity.
- From spatial measures to flood storage reservoirs
- From non-structural measures to flood warning systems, real time operation of reservoirs, preservation and increase of retention capacity
  Mobile (emergency) systems
Investment in Austria by the Federal Ministry from 1971-1990

- New dikes, river training: 3 151.8 km
- Maintenance works of dikes: 11 598.3 km
- Newly flood protected area: 71 547.8 ha
- Drained areas: 23 875.0 ha
- Annual federal investment in flood protection: 65.54-100 Mio. €

* Index according to Maculan/ Federal Chamber for Construction Works
The Change in Strategy

• In the 1980’ies it was recognised that the maintenance costs for bank protection and flood protection measures are continuously growing

• The change in agricultural policy does not require anymore flood protection measures for agriculturally used areas

• The losses in inundation areas (retention capacity) create new problems

• The adverse ecological impacts became obvious
From Single Actions to an Integrated Approach

• Instead of single measures a basin wide approach was proposed
• From a single objective approach (flood protection improvement) to a multi-objective framework considering also the ecological functions of a river
• From classical engineering measures to non-structural measures
• From bureaucratic decisions to an open society
The River Basin Approach: The “Vision Concept” or “Prototype Model”

Objectives:

- The flood protection for residential areas should be improved
- The retention capacity in the basin should be enlarged
- The ecological state of the riverine system should be preserved or improved
- The public should be integrated in the decision making approach
The River Basin Approach: The Concept

- The basis will be a risk zonation map and a vision of the river basin (not necessarily feasible !!)
- The vision should integrate (and harmonise) the long term objectives. The prototype should be the “Natural river basin”
- There should be a long term action plan which will be step wise implemented
- The plan should be comprehensive and integrative and open
- There should be a monitoring program to review the efficiency of taken measures
The Project

Project area

Integrated Flood Risk Management
The Situation: A Channelised River
The River Basin Approach: An Example

Risk zonation along a torrent: A detailed scale is needed
The River Basin Approach:

Risk zonation along a river: larger scale and other design criteria
What Are the Problems?

Sediment regime and morphology

River bed degradation

EINTIEFUNGSTRECKEN (max. 1.5 m)
Degradation of the River Bed

Longitudinal profile: in the average about .6 m in 25 years
What Are the Problems?

Improving the flood protection for the villages

Deficits in flood protection

Local measures for villages
What are the Principles for Measures?

• Consideration of the river regime (prototype)
• Creating variability and dynamics in the river bed
• Increase the retention capacity of the catchment
• Stimulate ecological improvement
• Improve Local flood protection of villages
• No flood protection for agricultural land
Some Measures

Consider the original state showing side arms and small islands

Stimulate bank erosion
reduce bed erosion
create variability
Monitoring of Taken Measures
Increase the Retention Capacity and Increase Morphological Variability

Creation of side arms
Some Other Examples

- Removal of bank protection and widening of the river
Summary and Conclusions (1)

Learnings from the past:

• Linear measures increase flow velocity, increase floods

• Flood reservoirs are preferential but specific costs are high

• Non-structural measures are of equal importance (buying land, transferring endangered farm houses, mobile or temporary flood protection systems, flood forecasting and warning)

• A basin wide approach is recommended
Temporary Flood Protection Measures
The River Basin Concept (2)

- Improve the flood protection of residential areas
- Increase the retention capacity in the basin
- Engineers, ecologists and regional planners collaborate in a team
- Land use has to consider the natural dynamics
- Involve the public
- Develop a stepwise approach which is based on the ‘historic’ and ‘unengineered’ river
Summary and Conclusions (3)

Actions at the legal and administrative level:

• Harmonisation of protection regulations among different institutions (eg. HQ$_{100}$ and HQ$_{150}$)
• Harmonisation of flood protection, land use and regional planning
• Harmonisation of upstream and downstream needs
• Information and incorporation of the public into the decision making process
Integrated Flood Risk Management

Risk Analysis
  Hazard analysis
  Damage Assessment
  Risk analysis

Reduction of the load
  Technical measures
  Non technical measures

Reduction of damages
  Technical measures
  Non technical measures

Emergency measures
  Warning systems
  Information systems
  emergency measures

Implementation:
  Bemessung
  Akzeptanz
  Realisierung
Thank you very much for your attention !!!!