

ESTIMATING THE COSTS OF EMERGENCY SERVICES DURING FLOOD EVENTS





Funding





Project Management



Projektträger Forschungszenirum Karlsruhe (PTKA)

Coordination







Introduction

- Emergency costs
- State of the art
- Flooding of 2005 in Tyrol, Austria
- Study design methods and data
- Variable description and results
- Summary and outlook









Accounting of the (avoided) costs of emergency services would in any case be an essential component for a comprehensive costbenefit analysis (CBA) of flood risk management programs

- costs for emergency services are substantial and important for the choice of risk management strategies
- Hurricane Katrina: approved government expenditure for emergency services amounts to more than US\$ 5 billion (3.7 % of the total economic loss)
- range of publicized percentages of costs for emergency varies from 2.2% (Freistaat Sachsen 2002), to 4.7% (Sachsen-Anhalt 2002); up to 10.7% in the U.K. (Penning-Rowsell / Wilson 2006) single cities, e.g. Magdeburg, Germany, report emergency costs of more than 14.7% in 2002 (Freistaat Sachsen 2002).
- empirical basis for estimating these costs are weak



costs of emergency services are costs borne by both, statutory and voluntary organizations, that aim to protect property and life from damages due to a natural disaster

- Costs by municipal services (army, fire brigade, police, medical service) in searching, rescuing, and evacuating people
- Costs of voluntary organizations for assistance to flood victims (providing food and shelter, health services etc.)
- Costs incurred by municipal services for flood control (sandbagging, pumping water out of flooded neighbourhoods)
- Costs to avoid the danger of water pollution due to leaking oil or chemicals
- Costs for protecting and safe-guarding buildings against structural damage and contamination



- Joy (1993) studies the direct and indirect costs of the flooding in a small city in New South Wales, Australia (Nyngan),
- Major evacuation: report on evacuation costs of 1.5 mill AUS\$, relief costs of 8.4 mill AUS\$ and clean up costs of 2.1 mill AUS\$



Penning-Rowsell and Wilson (2005) studied the emergency expenses of 58 counties in the U.K. during a major flood event in 2000



REBEL group (Morselt et al. 2007) summarize findings of international studies on emergency costs

- they find that most foreign studies does not fit to the situation in the Europe, mainly because of differing geographic, socio-economic and governances structures. For example, the distances of travel for evacuating people are much larger in Australia than in Holland
- Iittle evidence from official sides or regional / local governments in assessing emergency costs triggered by natural hazards, especially floods
- Austria: statistical basis for estimating costs for emergency, evacuation und clean-up is missing
- main reason for this obstacle is the involvement of different institutions and voluntary organisations if catastrophes or state of emergency are becoming emergent

Province of Tyrol, Austria



Flooding of 2005 weather situation and processes

- combination of a trough near the Adriatic Sea and heavy orographic precipitation in the western regions of Tyrol
 - "Vb"-weather situation (normal situation: trough condition, low snowline and only precipitation at luv-sided mountainous regions in the far-western and northwestern catchment areas)
 - precipitation over almost all catchment areas of the river Inn caused the once-incentury flooding event
 - August 2005: surplus in precipitation

Risk management of extreme flood events

- high intensities of more than 10 mm/h (daily precipitation rates of more than 100 mm in the west of Tyrol)
- return periods of water gauges of 5.000 years caused overall an estimated 1.325 hectares inundation area upon the rivers in Tyrol
- major river of Tyrol, Inn, at the gauge Innsbruck monitored the highest rate of flow ever measured (1.511 m³/s).

Separation into two process fields:

- rock falls, landslides and wet land slides (debris flows) in mountainous regions
- flooding, overflowing of river bodies and raising ground water levels in glacier formed valleys and low terrains
- It seems to be typical for alpine regions that the combination and mixture of processes triggers the high total economic losses due to flood events





Risk management of extreme flood events

Affected areas: Province of Tyrol





- ▲ economic loss of 410 mill €
- ▲ 2.1% of the gross regional product (2002 basis, total GRP 19,2 billion €)
- A affected in total 61 of 279 municipalities (30.500 inhabitants)
- main damage region consists about 20 municipalities
- 1.200 structures affected
- 25% of these structures are part of trade and industry





- high number of enforced members of fire brigades and other local volunteers (up to 13.400 per day)
- Additionally approximately 1.500 members of the armed forces, police and Red Cross produced in total 320.000 mission hours
- 15 private and army helicopters evacuated approximately 450 people
- several days airborne supply

Risk management of extreme flood events

several negative effects and regional economic impacts

- endangerment of industry and trade location, due to interruptions of transport sector
- a decline of supply on the tourism sector, due to partly or total destroyed structures
- market breaks of affected municipalities as a result of interruption of traffic
- finally partial breakdowns of telecommunication and energy supply for days





- Sample size: N=98 (municipalities with flood areas)
- maximum likelihood estimate to investigate the effects of a single flood event
 - ▲ questionnaire data of local fire brigades (N=325, response approx. 49%)
 - involved men of local fire brigades and volunteers
 - sum of service hours
 - clean-up as percentage of the sum of service hours
 - the losses of local fire brigades
 - the total costs of emergency
 - total private and public losses of the municipality
 - permanent settlement areas, inhabitants
 - data on disaster relief spending by Austrian catastrophe funds
 - GIS-data which describes the flood event (digitalized data of the flood event by aerial photographs of inundation areas)
- estimate a function for clean-up, the losses of local fire brigades and total service hours

Variable description and results total service hours / clean up

- Iog (hours) = 3.29 0.43 log (inhab) 0.27 log (area) + 0.33 log (inund) + 1.6 (days)^{***} + 1.17 log (add haz)^{***} + ε
 *** = significant at 10% level; r² = 0.426, r²_{adj} = 0.32
- Iog (clean up) = 2.35 + 0.06 log (inhab) 0.14 log (area) + 0.37 log (inund) * + 0.37 (days) + 0.43 (add haz) *** + ε * = significant at 1% level, *** = significant at 10% level; r²= 0.497, r²adj.= 0.404
- Negative effects: Inhabitants, permanent settlement area
- Strong impact:

- Duration of the flood event
- add haz (occurrence of multiple extremes such as debris flows, rock falls etc. in the observation area)



Permanent settlement area and "Multihazards"



Variable description and results

total costs of emergency services

Risk management of extreme flood events

▲ summing up the money equivalent of service hours, i.e. services hours multiplied with an average hourly wage of 38 €

▲ total costs of emergency services 6.4 mill €

- Comparing this cost with the total cost per municipality, consisting of the damages to private buildings and public infrastructure and the total costs of emergency services, we arrive at share of services costs 37 %
- Median value is much higher (76 %) because emergency costs are often the only costs incurred in most municipalities





Total emergency costs

share of emergency costs over the total cost per municipality

Risk management of extreme flood events

- A share of emergency costs is relatively high in cases of low and moderate damages (below 125.000 €) and decreases as the amount of damages increases
- A at very high total costs (> 0.5 Mill. €) we find shares of emergency spending beyond 30%. Given this high variance and functional relationship, we find that average values can be misleading as a rule of thumb to establish the costs of emergency services



total costs (€)

Summary and outlook

A alpine regions are specifically exposed to natural hazards

Risk management of extreme flood events

marginal permanent settlement area (average12 % Tyrol) – land use planning



- frequent coincidence of the appearance of multiple hazards in alpine lateral valleys are typical for these regions (floods, debris flows, rock falls)
- main finding: flood duration and the occurrence of multiple hazard have both a strong significant impact on the total hours spent on and thus the costs of emergency service
- "special vulnerabilities": empirically unobserved characteristics of the location
- Improvement of homogeneity of flood measures (inundation, return periods) and economic losses, validation of the estimated cost functions

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