The importance of active public communication - Settlement systems and land use patterns seen from a disaster perspective

Christoph Aubrecht, Mario Köstl, Markus Knoflacher, Klaus Steinnocher

(Mag. Christoph Aubrecht, Austrian Research Centers GmbH – ARC, systems research, Donau-City-Straße 1, 1220 Vienna, Austria, christoph.aubrecht@arcs.ac.at)
(Mag. Mario Köstl, Austrian Research Centers GmbH – ARC, systems research, Donau-City-Straße 1, 1220 Vienna, Austria, mario.koestl @arcs.ac.at)
(Dr. Markus Knoflacher, Austrian Research Centers GmbH – ARC, systems research, Donau-City-Straße 1, 1220 Vienna, Austria, markus.knoflacher @arcs.ac.at)
(Dr. Klaus Steinnocher, Austrian Research Centers GmbH – ARC, systems research, Donau-City-Straße 1, 1220 Vienna, Austria, klaus.steinnocher @arcs.ac.at)

1 ABSTRACT

The presented paper deals with urban land use strategies related to natural hazards and points out the importance of active public communication as an essential task of regional planning for reducing community vulnerability and damage potential accordingly. The huge 2005 flooding event in Western Austria serves as case study for analyzing damage cost patterns referring to documented damage cases provided by the Federal State Government. Results lead to the assumption that distorted human risk perception is an important factor for increasing vulnerability, as technically protected areas feature much higher average damage costs per building than unprotected areas with a certain risk acceptance and presumably better preparedness.

2 INTRODUCTION

Living in areas at risk from natural hazards is a commom phenomenon particularly in mountainous regions (e.g. large parts of Austria). Increasing land consumption and land demand entail further expansion of settlement systems to areas with known potential for hazard impacts such as floods, landslides and avalanches. Regional land use planning concepts define formal levels of 'acceptable' risk (e.g. frequent event, design event, see tab. 1), but whether this residual risks are perceived as such by the public is a topic often not being addressed.

With a general increase of extreme events as predicted e.g. by IPCC in its Fourth Assessment Report (2007) flooding will become more frequent and thresholds of acceptable risk have to be reconsidered. Planning actors on all levels are requested to play an active part in comprehensive and sustainable hazard management. Metaphorically spoken, just 'elevating the levees' is probably not the exclusive solution. Active public communication and integration of all parties including local residents is a first step to coping with future problems in termes of hazards and risks in a sustainable and effective way.

3 URBAN LAND USE STRATEGIES AND NATURAL HAZARDS

Urban land use strategies are in many cases controlled by certain given rules and guidelines or even strictly bound to specifications given by law. In Austria, zoning plans and related concepts are e.g. defined by the Land Use Planning Law which regulates the process of organizing the use of lands and their resources to best meet people's needs over time, according to the land's capabilities (Steinnocher & Köstl 2007). Besides various other points such as protection of natural as well as anthropogenic environments, risk reduction in terms of natural hazards is one of the major objectives.

Furthermore the Austrian Conference on Spatial Planning (ÖROK) works out and maintains the so called 'Austrian Spatial Development Concept' (ÖREK; current version: ÖREK 2001 as described in ÖROK 2002) which can be seen as a mission statement for spatially relevant planning and measures on national, regional and local scale. One topic specifically highlighted is that 'dealing with natural hazards is to be seen as a regional planning task'.

It is stated that *"…handling of natural hazards and the related process of revision and/or extension of official hazard maps has to include both long-term monitoring of damage potententials and new findings on specific hazard causes."* Furthermore *"regional planning is asked to prevent the emergence of additional hazard potentials when judging spatial development processes".*

The last statement indicates that precautionary risk assessment and mapping is of utmost importance when it comes to legally binding decisions and planning measures. Within the Austrian 'Hazard zone mapping regulation' (according to the Decree of the Ministry for Agriculture and Forestry of July 30, 1976) hazardous

processes are identified (10 and 150 years event) and different hazard zones are determined. The following table (tab. 1) shows the criteria for delineation of flood hazard zones in Austria.

Frequency estimates such as the magnitude determination of the event featuring a 150 year return period include a high degree of uncertainty. Dealing with such time periods can further lead to a distorted human risk perception, as people living in potentially endangered areas ignore the risk and think that such an event will not happen anyway during their life time (compare chapter 4).

Hazard zone	Frequent event (10 year)	Design event (150 year)
Red zone	energy line > 0.25 m	energy line < 0.25 m
Yellow zone	energy line > 1.5 m	energy line < 1.5 m

Tab. 1: Flood hazard zone delineation in Austria.

As described by Petrov et al. (2005) with regard to flood risk, the most significant damage is caused where the risk is increased through inappropriate housing in high-risk areas or through serious interference in natural processes. The exposure of flooding therefore can and has to be reduced to a minimum by policy and regional planning through sustainably controlling land use management and housing development.

While the best solution would be to completely avoid hazardous areas, this is actually not always practical and feasible in urban areas (Perkins 2006). The objective of spatial planning and regional development thus has to be to reduce the levels of community vulnerability to potential hazards (Godber 2002). Flood risks are considered in different ways in urban development and management (Lavalle et al. 2005).

- The *adaptive approach* regulates particular land use activities in areas with high flood risk by establishing protection zones with different restrictions. Adaptation measures are for example construction ban in certain areas or obligatory construction measures for the reduction of the vulnerability of buildings.
- The *technical approach* comprises measures for the reduction of flooding probability by technical measures such as levees, dams and channel improvements.

However, the effects of flooding events are not directly related to such measures, because of two main reasons. One reason is the long-term dynamic of flood events, i.e. the more extreme the event, the lower its probability. It requires social and economic decisions about the dimensions of appropriate protection measures and about the accepted residual risk (Godber 2002, Voortman et al. 2001) of very rare but large flood events. The other reason is human risk perception (Raaijmakers et al. 2008), strongly influencing the public opinion and final political decisions about measures for risk prevention. So, increasing public risk awareness (Van Gelder 1999) is the first step towards a successful reduction of community vulnerability.

4 HUMAN RISK PERCEPTION

The analysis of documented damage data recorded at the severe 2005 flood event in the western part of Austria (Aubrecht et al. 2009) confirms that the actual impact of natural disasters is not directly related to pre-installed risk-reducing measures (compare chapter 5). Protection measures providing safe conditions until a certain threshold often lead to distorted human risk perception. Flood protection through levees and dams eliminates the hazard of flooding up to a certain flood dimension. The residual risk of rare but very large floods is not perceived as such by humans.

Built-up areas are extended to these ‘risk-freed’ regions without considering the residual flood risk. This increases the probability of high damage costs and direct impact on humans (e.g. casualties) as a consequence of flood events exceeding the protection capacities of technical measures.

Risk is generally defined as a concept incorporating hazard (H) and vulnerability (V), whereas it is common to express risk (R) as a complex functional relation of hazard and vulnerability:

$R = \{H\} \times \{V\}$

Human risk perception and public risk awareness can be seen as one important factor in overall natural hazard related vulnerability. Pistrika & Tsakiris (2007) describe a set of factors being essential for vulnerability assessment in flood prone areas. They subsequently define a vulnerability function (f_V) which is slightly adapted in this case to fit to the concept of the presented paper:

V = f (E, CC, SR, I)

where the Vulnerability of a system (*V*) is a function (*f*) of

E … being the exposure of the system,

CC … being the initial coping capacity of the system,

SR … being the social response of the system (including early warning, public awareness a.o.), and

I … being a fuzzy term considering the various interrelations of vulnerability factors (e.g. coping capacity and exposure)

According to Kötter (2003) comprehensive vulnerability analysis for disaster-prone areas has to incorporate "information about past disaster events, the socio-economic conditions of the population living in the affected area, and inventories of major structures liable to damage". The case study presented in chapter 5 is based on documented damage cases, and results of the spatial analysis can be a valuable input for future risk mitigation measures.

Referring to the factor of social response included in the vulnerability function, active public communication can play an important role in disaster mitigation and prevention. A well informed society being aware of environmental risks and hazards and understanding that it is impossible to achieve zero risk (Motoyoshi 2006) is less vulnerable to certain natural events, which is eventually reducing disaster impacts and damage costs. Output of the presented case study can strengthen the argumentation in that context.

5 CASE STUDY - FLOODING EVENT 2005 IN VORARLBERG, AUSTRIA

The extraordinary dimension of the flood events in 2005 in the Austrian province Vorarlberg offers the opportunity for analyses of the effects of land use strategies on damage costs. Settlement areas protected by dams and leeves were flooded because of dike breaches and dam failures at the same time as technically unprotected settlement areas. Spatial analyses have been carried out integrating building damage cost values and information on dedicated hazard zones as well as geo-hydro morphological preconditions.

A set of damage cases recorded at the 2005 flooding event was provided by the Federal State Government of Vorarlberg. A detailed description of the event including hydrological and weather data as well as a broken down list of thematic topics regarding documented damage can be found in Kanonier (2005). The European Flood Report 2005 gives overall damage estimations related to rail and street network (Hilfiker et al. 2005). Rudolf-Miklau et al. (2007) provide a description of the internationally standardized procedure (DOMODIS: Documentation of Mountain Disasters) used for disaster documentation in this specific event.

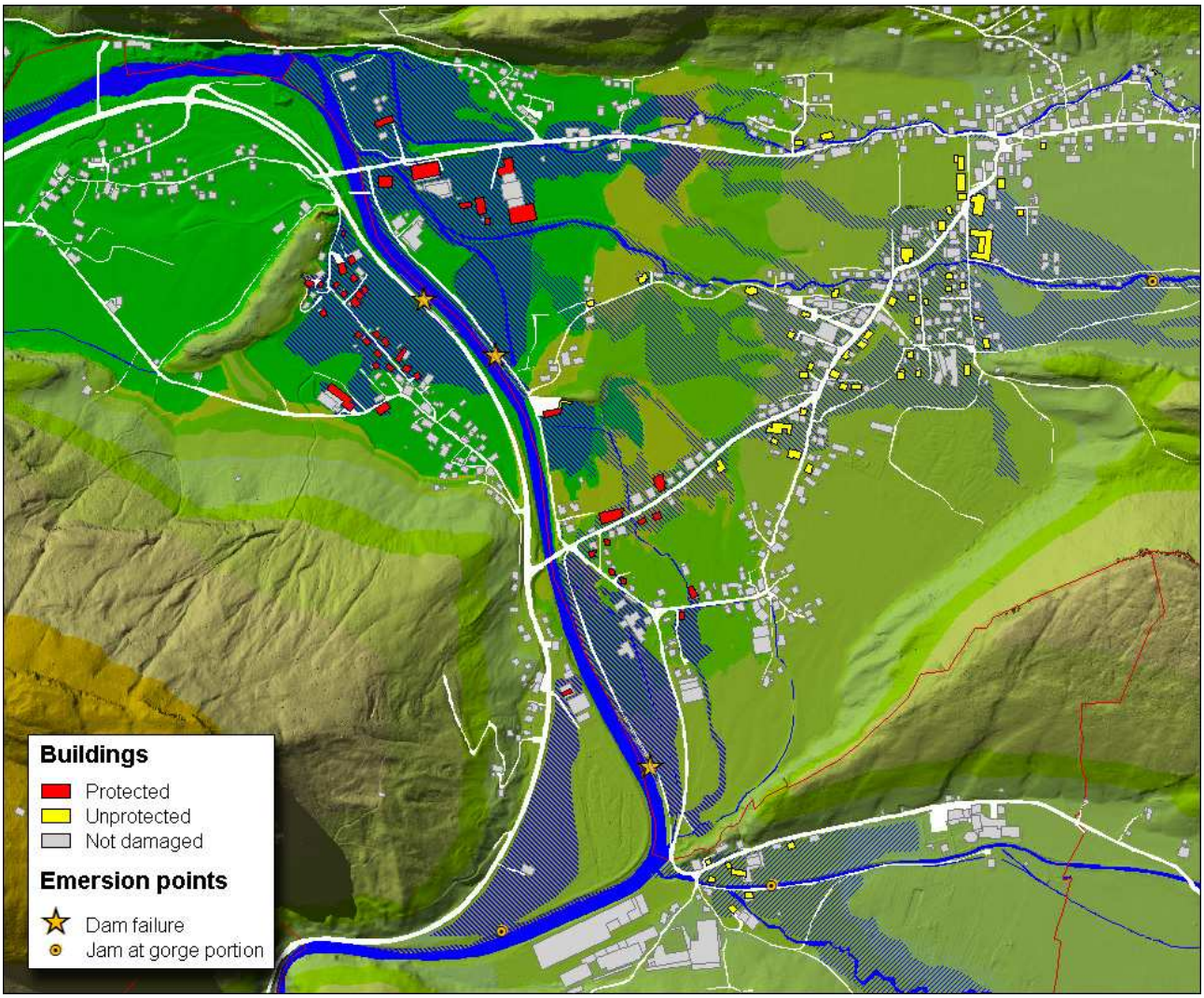

Fig. 1: Distinguishing damage on buildings in protected areas and unprotected areas.

An integrated analysis considering the available damage data together with information on dedicated hazard zones, pre- and post-disaster aerial imagery and a digital elevation model allowed separating damage causes. Emersion points related to dam failures and breached levees could be identified, subsequently enabling the detection of damaged buildings located in areas with installed protection measures (hence called 'protected areas'). Areas where jams at certain gorge portions (e.g. small bridges) had been the cause for emersion could be delineated as well as areas where damage had resulted from gradual river overflow (hence called 'unprotected areas').

Figure 1 shows a detail of the study area with buildings in 'protected areas' marked in red and buildings in 'unprotected areas' marked in yellow. All other building objects with no documented damage are grayed out. Furthermore the identified emersion points are labeled and the delineated flood plain is visualized.

Damage in 'protected areas' (dam failures and breached levees)				
Hazard zone	Number of cases	Average value	Minimum value	Maximum value
Zone of pot. flooding	5	1,270,600	200,000	4,195,000
Yellow zone	5	73,140	700	250,000
Red zone	2	-	1,500	7,000
Out of zones	33	75,567	1,700	1,500,000
Total	45	204,909	700	4,195,000

Damage in 'unprotected areas' (overflowing of river banks)				
Hazard zone	Number of cases	Average value	Minimum value	Maximum value
Zone of pot. flooding	9	341,561	3,000	2,750,000
Yellow zone	1	-	3,000	-
Red zone	0	-	-	-
Out of zones	44	21,772	1,000	160,000
Total	54	74,723	1,000	2,750,000

Tab. 2: Flooding damage in protected areas vs. damage in unprotected areas.

Table 2 is structured in two separate parts, the first listing the documented damage cases in 'protected areas' (PA) and the other showing the damage in 'unprotected areas' (UA). When comparing the two distinguished regions regarding the average damage cost per building PA feature a much higher value than UA (€ 204,909 vs. € 74,723). Within these areas buildings are further classified according to their location in red and yellow hazard zones and potential inundation zones (with favorable geo-hydro morphological conditions).

In PA, i.e. areas protected by technical measures and therefore likely to be perceived as "risk-freed" by the public, two cases are reported in the red zone (featuring regular construction ban) and five cases are reported in the yellow zone (featuring restrictions for building construction). However, both the higher average damage costs and the maximum values are reported in potential inundation zones, being approximately 16 times higher than the average damage costs outside of hazard protection zones.

On the one hand this points to a successful technically reduced vulnerability of buildings being located in hazard zones and on the other hand the results indicate that areas with flood-favorable geo-hydro morphological conditions are potential damage hot spots in settlement areas, even if they are protected by technical measures. The assumption is that the higher average damage costs in PA result at least to some extent from a general unawareness related to the residual risk, thus amplifying overall vulnerability. Without a doubt regional planning and policy can play an important role in communicating risk-related issues to the public – an effective and comparatively easy way of reducing community vulnerability and flood risk accordingly.

6 CONCLUSION

This paper presents concepts of urban land use strategies related to natural hazards and risk. Risk is defined as a complex functional relationship of hazard and vulnerability, whereas human risk perception and public awareness are important factors in terms of the social response of a system adding to its overall vulnerability. A case study a.o. referring to documented damage data from the 2005 flooding event in Western Austria confirms that technical protection measures do not necessarily lead to a direct reduction of damage costs. Due to distorted public risk perception vulnerability increases and damage can be even higher in such areas when a hazardous event exceeds a certain threshold (being predefined as acceptable risk). The presented analysis approach and respective results are of high interest to researchers and authorities involved in urban and regional development as well as disaster and emergency management.

7 ACKNOWLEDGMENT

The presented work was funded by the Austrian Research Promotion Agency (FFG) in the frame of the Austrian Space Applications Programme (ASAP).

8 REFERENCES

AUBRECHT, C., M. KÖSTL, M. KNOFLACHER, K. STEINNOCHER (2009): Regional assessment of damage potential considering functional building patterns. In: Konecny, Zlatanova, Bandrova, Friedmannova (eds.) Cartography and Geoinformatics for Early Warning and Emergency Management: Towards Better Solutions. Proceedings (pp. 42-50), CD-Rom. Prague, Czech Republic, January 19-22, 2009.

GODBER, A. (2002): Urban Floodplain Land-use – Acceptable Hazard?: A Case Study of Flood Risk Perception on the Gurangunbah Floodplain (Nerang River System), Gold Coast. Social Change in the 21st Century Conference. Proceedings. Queensland University of Technology.

HILFIKER, H., J. TOOTHILL, S. SCHNEIDER, J. ALOVISI (2005): European Flood Report 2005 – Central and Eastern Europe. Guy Carpenter & Company Ltd., New York, NY, USA. 20 pp.

IPCC (2007): Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team: Pachauri, R.K., A. Reisinger (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

KANONIER, J. (2005): Das Starkregen- und Hochwasserereignis des August 2005 in Vorarlberg. Ein Bericht des Amtes der Vorarlberger Landesregierung. 54 pp.

KÖTTER, T. (2003): Prevention of Environmental Disasters by Spatial Planning and Land Management. 2nd FIG Regional Conference. Marrakech, Morocco, December 2-5, 2003.

LAVALLE, C., J.I. BARREDO, V. SAGRIS, M. GIERK, A. DE ROO, J. THIELEN (2005): Integrating Flood Mitigation in Spatial Planning. ICID 21st European Regional Conference 2005. Frankfurt (Oder) and Slubice, Germany and Poland.

MOTOYOSHI, T. (2006) Public Perception of Flood Risk and Community-based Disaster Preparedness. In: Ikeda, Fukuzono, Sato (eds.) A better integrated management of disaster risks: Toward resilient society to emerging disaster risks in mega-cities. Tokyo, Japan: Terrapub. 121-134.

ÖROK (2002): Österreichisches Raumentwicklungskonzept 2001. Österreichische Raumordnungskonferenz (ÖROK), Vienna, Austria. 189 pp.

PERKINS, J. (2006): Land Use in Hazard Areas – Risk Management and Public Policy Opportunities. ABAG Earthquake and Hazards Program. Local Hazard Mitigation Plan – Mitigation Policy Review. Oakland, CA, USA.

PETROV, L.O., J.I. BARREDO, C. LAVALLE, V. SAGRIS, A. DE ROO, M. GIERK, E. GENOVESE (2005): Adaptation strategies for flood mitigation in the urban environment: The case study, Friuli-Venezia Giulia (FVG), Italy. International conference on innovation advances and implementation of flood forecasting technology. Tromsø, Norway, October 17-19, 2005.

PISTRIKA, A., G. TSAKIRIS (2007): Flood Risk Assessment: A Methodological Framework. Water Resources Management: New Approaches and Technologies. European Water Resources Association, Chania, Crete-Greece, June 14-16, 2007.

RAAIJMAKERS, R., J. KRYWKOW, A. VAN DER VEEN (2008): Flood risk perceptions and spatial multi-criteria analysis: An exploratory research for hazard mitigation. Natural Hazards, 46(3), 307-322.

RUDOLF-MIKLAU, F., A. ELLMER, H. GRUBER, J. HÜBL, K. KLEEMAYR, E. LANG, F. SCHMID, I. SCHNETZER, C. WEBER, M. WÖHRER-ALGE (2007): Documentation and analysis of the 2005 disaster in Austria caused by floods and mass-movements: Methods and results. EGU General Assembly 2007. Geophysical Research Abstracts, Vol. 9, EGU2007-A-00703. Vienna, Austria.

STEINNOCHER, K., M. KÖSTL (2007): Mapping urban function by integrating socio-economic information, address data, and remote sensing. 2007 Urban Remote Sensing Joint Event, Paris, France.

VAN GELDER, P.H.A.J.M. (1999): Risks and safety of flood protection structures in the Netherlands. Proceedings of the Participation of Young Scientists in the Forum Engelberg 1999 on Risk and Safety of Technical Systems - in View of Profound Changes, pp. 55-60.

VOORTMAN, H.G., M.D. PANDEY, P.H.A.J.M. VAN GELDER, J.K. VRIJLING (2001): Definition of acceptable risk in flood-prone areas. In: Corotis, Schuëller, Shinozuka (eds.) Structural safety and reliability – Proceedings of the 8th International Conference, ICOSSAR'01. Newport Beach, CA, USA, June 17-22, 2001.