The 2005 Flood and Sediment Disaster in the Western Parts of Tyrol/Austria — Facts und Conclusions

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Abstract

In August 2005 the western parts of Tyrol have been hit by a flood disaster with a recurrence probability of up to 5000 years, caused by a heavy rainfall period of 30 hours on presaturated soils. Severe damage has been done to public facilities and private property especially in torrential river catchments by flooding, undercutting of banks and bedload depositions summing up to estimated € 350 millions. Torrent tributaries responded to that rainfall only in case of quite large catchments; despite the saturated soils no large landslides have been triggered or reactivated. Not only results and conclusions of evaluating existing torrent control works and hazard zone maps are discussed in this report, but also necessary consequences for a better planning and an improved disaster preparedness in the future.

Keywords: flood and sediment disaster, torrent control works, hazard zoning

Meterological situation

The flood and sediment disaster in the period 22^{nd}–23^{rd} of August 2005 in Tyrol (but also in Vorarlberg) has been caused by the so-called Vb-cyclone with a low pressure area in Northern Italy south of the Alps. This cyclone first brought heavy precipitation in the Southeast of Austria, than moved to the East and circled back to the Alps, which led to extreme rainfall north of the main water divide.

Based on measured data a regional assessment of precipitation heights in the 24-hours period 07.00/22/08 to 07.00/23/08 resulted in values from 130–160 mm in the District of Reutte and in the District of Landeck from 120–130 mm (Stanzer Valley) to 70–120 mm (Paznaun Valley).

The following circumstances led to extreme runoff values:

- Not the intensity, but the long period of constant heavy rain from the morning of the 22^{nd} to the noon of the 23^{rd} of August has been extraordinary for the Northern parts of the European Alps.
- Whole valleys and large catchment basins have been rained over completely.
- The 0 ° C-line lay high in an altitude of 2800 m a.s.l., therefore practically all precipitation fell in form of rain.
- The snow packs of last winter had been melted already, therefore there were no positive snow-pack retention effects.
- Soils had been presaturated to a high degree by rainfall a week before, thus reducing their retention capacity.

Flood runoff values

The described facts resulted in extreme runoff, which in some cases had never been measured in the region before (Table 1).

Resulting flood and sediment disasters

Torrents have relatively small catchments (in Tyrol up to 100 km^2) and respond with disastrous effects in most cases only to thunderstorm rainfalls with short duration, but high intensities. This has been not the case, therefore no debris flows were triggered.

According to the special rainfall characteristics disastrous events took place only in torrent catchment basins larger than 10 km^2. Fig. 1 shows a map with the location of the following pictures (Fig. 2–7).

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Table 1. Characteristics of torrential moutain rivers.

Catchment name	Gauge location	Catchment area (km^2)	Floodpeak (m^3/sec)	Frequency in years	Comments
Lechriver	Steeg	247,9	361	~ 5000	
Lechriver	Lechaschau	1012,2	943	» 500	
Rosanna river	St. Anton	130,6	(» 54)	(» 100)	Gauge destroyed 22.08 (21.30)
Trisanna river	Galtuer	97,6	> 141	~ 5000	
Sanna river	Landeck	727,0	514	~ 5000	
Inn river	Innsbruck	5792,0	1511	≥ 200	

The dominating processes were erosion of older bedload deposits in middle reaches and lateral bank erosion in outer curves (Fig. 2). The sediment loads were transported in waves down to the alluvial cones and deposited here in form of layers (Fig. 3). At the junctions of torrent tributaries with the rivers overlapping sediment deposition processes resulted in extreme problems and in an almost total flooding of the flat mountain-valley floors (Fig. 4).

In torrential mountain rivers (Lech, Rosanna, Trisanna, Sanna) not only very high flood runoff values have been observed, but also extreme sediment transport and deposition processes, as well as severe lateral erosion took place (Fig. 5). These processes devastated the valley floors and changed the valley morphology in combination with tributary torrents considerably.

Despite the high soil saturation landslides played only a small role in the Tyrol.

The 2005 flood and sediment disaster led to devastations in the mountain valleys Lechtal, Stanzertal and Paznaun (Fig. 6), located in the western parts of the Tyrol. It was much luck, that only one person has come to death by the disaster. A working man in a carpentry was killed by a 40 m^3-boulder, tumbling down a mountainside in the Oetz Valley. This boulder had been lying imbedded in a talus cone and was underwashed and triggered by a small debris flow.

A rough first estimation of damage done to public infrastructure facilities and private property in the Tyrol resulted in costs of app. 350 million € , caused mostly by torrential rivers.

Economics in the considerably devastated valleys are based to a very high degree on tourism, starting more or less 50 to 60 years ago. Up to that time the rural population in these valleys settled mostly at suitable localities on the mountainsides, especially on south-looking slopes, and on the debris cones of tributaries. Old maps show only a handful of farms located on the flood-prone valley floors. After the end of the second world war the number of touristic buildings grew excessively, especially in the Paznaun and Stanzer Valley as result of the development of famous ski areas. This development of course was accompanied also by a moderately rising number of population and of residential houses. Because the old favorable building sites had been occupied already, most of the new buildings had to use sites on the valley floor. In the first decades this building boom took place in times with no or little restrictions by land-use or development planning laws. On the one hand the damage costs were enormous, but on the other hand there is no alternative to tourism in the high-mountain valleys of the European Alps. Without tourism there would be no prospering communities, but decreasing population numbers and an economical decline.

Comparison of hazard zoning and 2005 disaster effects

Disastrous events of low frequency offer the chance to evaluate existing hazard zone maps and to learn for future hazard zoning activities.

Up till now this has been done only for the torrents (competence: Austrian Service for Torrent and Avalanche Control) and not for the valley rivers (competence: Austrian River Works Agency).

Such an evaluation of course has to be based on the assumption, that the 2005 disaster has been equivalent to the design event for hazard zoning in Austria with a recurrence probability of 150 years. We cannot know that, but it is obvious, that for the torrential mountain rivers the frequency has been calculated to be much lower.

Because of overlapping processes at least the evaluation results at the junctions of torrent tributaries with rivers should be looked at with some reservation.

The evaluation of several torrent hazard zones differing with the disaster-hit areas in Tyrol and Vorarlberg brought the following results: - The outer boundaries of the Yellow Zones corresponded quite well with disaster-hit areas.

– In some cases parts of the junction area of torrent tributary and river proved to be not Yellow, but Red

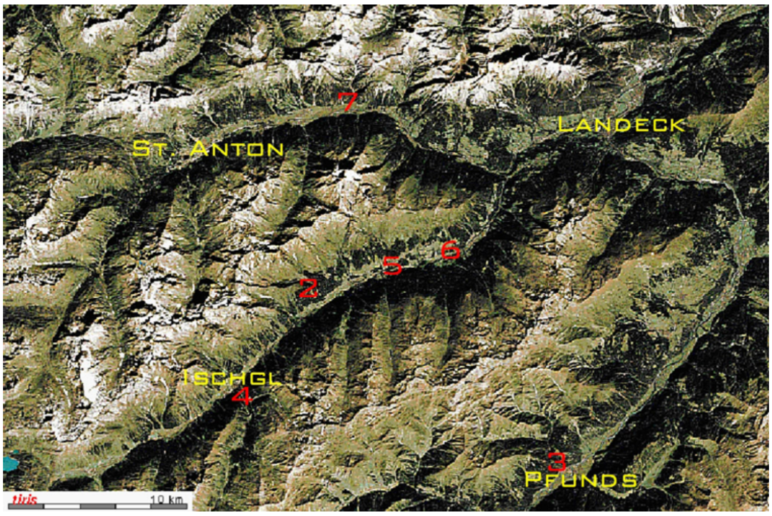

Fig. 1. Orthofoto of Paznaun, Stanzer and Upper Inn Valley with the locations of the following pictures (Fig. 2–7).

Fig. 2. School building destroyed by lateral erosion (Torrent Sessladbach, Paznaun Valley).

Zones according to Austrian hazard zoning criteria.

- In two cases technical control works have been destroyed (earth dam, old channel works) or didn't function as expected (debris-sorting Sabo dams, channel works), resulting in new or larger Red Zones.

Conclusions for hazard zoning (lessons learned):

- At the junction of tributary torrents with rivers overlapping processes of sediment deposition and channel shifting will have to be taken more into account (Fig. 3). This needs an improved cooperation between torrent and river control institutions, not identical in Austria.
- Possible negative effects of trees and logs (woody debris) jamming bridges and narrowings will have to be consequently taken into consideration.
- In case of heavy sediment loads or debris flows the protective effects of channel works alone without additional sediment retending basins or consolidation of debris sources by check dams are insufficient.
- Old technical control works have to be studied critically concerning their functioning and their stability in case of design event stresses.

Fig. 3. Deposition of heavy sediment loads on the debris cone of the Torrent Stubenbach (Upper Inn Valley).

Fig. 4. Junction of the Torrent Fimberbach with the River Trisanna (Paznaun Valley).

– Much damage could have been avoided by the construction of flood-proof buildings. This would need a better control of protecting specifications in building permits prescribed by the Torrent and Avalanche Control Service.

Evaluation of technical torrent control works and conclusions (lessons learned):

An investigation evaluating the functioning of torrent control works during the 2005 disaster brought the following results:

– Technical countermeasures have mostly worked well and prevented or reduced much higher damage. The 2005 disaster proved once more, that investigations in control works do not only pay off financially, but are essential for people living in mountainous regions.

– Once again there have been problems resp. negative effects by woody debris regarding the functioning and stability of Sabo dams. Logs and trees jamming discharge sections resulted in overflowing the whole

Fig. 5. House destroyed by lateral erosion (River Trisanna, Paznaun Valley)

Fig. 6. Total flooding and devastation of the valley floor (River Trisanna, Paznaun Valley).

crown of dams with problems for foundations and downstream banks. In the future overdesigning of discharge sections and an improved forest management in torrential catchments to reduce woody debris will be necessary.

– An up till now unknown phenomenon took place in two cases of open sediment-retention dams with large holes or filtering steel constructions in catchments with fine-grained debris. Such constructions are relatively new developments, but up till 2005 they functioned very well. Probably the special situation of 2005 (long period of heavy rain, but no short, very intensive thunderstorm rainfall) led to only temporary sediment depositions, which were eroded again later by the same flood, leaving the retending basins almost empty (Fig. 7). Large openings of sediment-retending or sorting Sabo dams therefore should be made much smaller, at least in case of fine-grained debris.

Fig. 7. Temporary deposition behind a sorting debris-retention Sabo dam, eroded again later by the same flood, leaving the retending basin almost empty (Schnannerbach, Stanzer Valley).

General conclusions for the future (lessons to learn):

- Flood and sediment disasters are phenomena ignoring legal or organizational boundaries. An improved cooperation between all organizations dealing with such catastrophes will be necessary.
- A standardized documentation of natural disasters in the European Alps will be essential to learn from past events for future activities, not only for better planning of control works, but also for improving all aspects of disaster preparedness.
- Standardized methods of analyzing and monitoring the technical conditions and stability of old control works will have to be developed (especially for Sabo dams).
- Torrents sufficiently controlled by technical countermeasures are only "dormant", their potential is still existing and can be triggered again in case of extreme events with much lower frequency than designed or by destruction of control works because of ageing. Especially in case of natural hazards dangerous for people's lives and health, like debris-flow torrents (or snow avalanches), a restrictive development policy for protected but still unsettled areas will be necessary in the future. Without such precautious restrictions we will leave increasing burdening problems to following generations.
- All sorts of passive measures preventing, reducing or mitigating the effects of disasters should be intensified, e.g. monitoring and warning systems, mobilization and evacuation plans, restrictive land-use and development planning, insurance of private property, support of rescue and aid organizations.

Concluding remarks:

The 2005 flood and sediment catastrophe offered once more a rare opportunity not only to Austrian politics, control services and Sabo engineers to learn for the future, but the lessons to learn are important for all mountainous regions in the European Alps and all over the world. It is now our turn to draw the necessary consequences from the 2005 experiences for the benefit of coming generations.

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