Austrian Experiences in Balancing Protection of People Against Flood and Sediment Disasters and Protection of the Environment--Ecology Without Sacrificing Safety

Christian Weber
Deputy Director
Austrian Ministry of Agriculture and Forestry, Environment and Water Management Department
WLV –Torrent and Avalanche Control Service
Technical Director
Austrian Society of Torrent-, Avalanche- and Erosion Control Engineers
Langgasse 88, A-6460 Imst, Austria
E-mail: christian.weber@wlv.bmlf.gv.at

ABSTRACT

"Ecological Engineering and Technology" has the main goal "Protection of people from flood and sediment disasters" and the secondary target "As little negative influence on environment and landscape as possible" as far as that can be done without interfering with the main goal. Such techniques cannot be used in torrent reaches, where debris flows may occur, and their application is restricted in densely settled or urbanized areas. This more practical orientated contribution will try to work out first the reasons, why the Austrian conditions are comparable to Taiwan's situation in land use in some cases and why the principles that apply to Austria might apply to Taiwan too. Secondly the report gives an overview on environment and landscape orientated targets and discusses short some aspects of the possibilities of the public administration (regulation, passive measures), limits and design principles for engineers working at torrents and mountain streams. As a result the report gives some illustrated examples from experiences made in Austria (active measures). At last there are some short remarks to the European Water Frame Directive that tries to improve the quality of the water streams and water bodies of Europe in the future.

1. Introduction

As response to the growing disapproval of the public opinion with mere technical countermeasures torrent engineers, water resources engineers and public administration try to plan and implement more "near-nature" control techniques in Austria (Europe) and other similar developed countries. Until now principles how to do this have been laid down just insufficiently. After decades of more or less mere technical torrent control measures public opinion looks at such works with growing disapproval. Environment and its protection rank high in people's minds and are of high social and political value. Undoubtedly rapid technical progress in building materials and construction equipment, together with the growing public prosperity after the second world war enabled and enforced technical countermeasures.

Control measures of former times had necessarily to be based on the use of timber and plants to a high degree. Many experiences of that time are very useful nowadays.

The base of all considerations is, that the main goal is the protection of the people and their activities from disasters and to diminish negative influences of defence works on the environment and the landscape as far as that secondary target can be reached without interfering with the main goal.

2. General Remarks

The terms “ecological engineering” and "near-nature techniques" are somehow misleading, because it is impossible to implement control works in a torrent or river channel, so that it is a natural and untouched mountain stream afterwards. Therefore the term "nature orientated" or "stream-ecology orientated" techniques seems to be better. Although "nature orientated" control techniques use "soil bioengineering" methods to a high degree, these two conceptions are not the same. "Nature orientated" control techniques combine both - technical and soil-bioengineering methods.

3. Why Taiwan – Austria

Austria has about 84.000 km². Similar to the situation in Taiwan a large part of this area is mountainous without little space for settlements. The villages are in the lower areas and valleys. In this situation for decades people tried to “win back” land from rivers (and other ecological valuable ecosystems).

The District Office "Upper Inn Valley", where the author comes from is responsible for all sorts of torrent, avalanche, rockfall and erosion control measures in the western part of the Tyrol, a federal country of Austria.

The area of this districts covers 3.320 km² (9,2% from the area of Taiwan), the population runs up to 96.000 inhabitants. It is among the most intensively used tourist regions in Austria with a high density of tourist infra-structure (especially ski-lifts and cable cars but also for summer tourists); overnight stays sum up to about 11,1 millions per year. This is why in Austria (especially in the federal country Tyrol) ecological orientated works became more and more important. Tourists want to consume an intact and beautiful landscape for recovery and relaxation.

Fig. 1. The district “Upper Inn Valley”, a mountainous area with little space for settlements and a high demand on the landscape for recovery and relaxation.

The area suited for settlements (sometimes called "Net-Tyrol") there is only 7,4 % of the total area. Referring to the area suited for settlements, the population density would be 391 inhabitants/km² (e. g. Taiwan 628 inhabitants/km²). As a result of all those facts it can be said, that the District Upper Inn Valley is among the regions with the highest hazard intensities in the Alps and with one of the highest population densities in Europe.

Protection from natural hazards here consists nowadays of 3 synergistic components, for which the District Office Upper Inn Valley is responsible alone or in cooperation with other organizations:

（1）Disaster prevention and mitigation measures, (e.g. hazard zoning, monitoring and warning systems, disaster preparedness in general)
（2）Defense works (technical and ecology orientated countermeasures of all sorts)
（3）Watershed and forest management (especially high-elevation reforestation – not really needed and useful in Taiwan)

The climate is continental with relatively hot summers and cold winters, the annual precipitation is quite low (800 – 2000 (3000) mm, up to 3000 mm in Taiwan and extreme precipitation in Typhoons). Thunderstorm rainfalls may bring intensities up to 100 mm/hour. Snow cover melting periods in spring may cause high runoffs in Torrents and rivers in Austrias mountainous regions.

4. Passive Measures – Retarding from Endangered Areas

Since the end of the second world war the mountainous regions of the Alps were developed and settled with rapidly increasing intensity; traffic and tourism all around the year in some areas almost “exploded”. Inevitably these activities were spread out to areas endangered by mountainous hazards and natural phenomena like floods, debris flows, landslides, rock fall and avalanches collided with human activities much more than in former centuries.

Consequently the efforts of people and governments on the field of active disaster defence by technical means were intensified, but taking future aspects into account, forward-looking people soon came to the conclusion, that the increasing problems could not be solved by active countermeasures alone on the long run.

Therefore all sorts of passive prevention measures were enforced; one of these and by far the most important lies in the restriction of development and settling by land-use planning in case these human activities conflict with mountainous hazards. For this task an assessment of such hazards and a delimitation of their boundaries is necessary. The basic content, the map, is based on chronicles, mathematical and modelling results, analogies and field works on hazard indicators, that shows the endangered area.

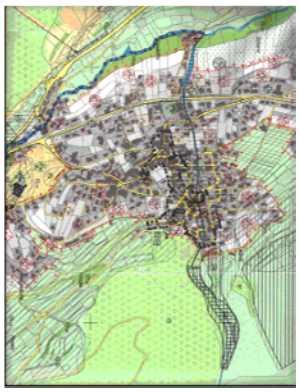

Fig. 2. and Fig. 3. Hazard Zone Map, left side Land use Map, right side

One result of the strategy of land use planning is, that there are less or no more expectations from people to settle in endangered areas and that we get increasingly more space for the needs of the nature in many ways.

Although these restrictions in land use are not popular, the Federal Government decided, that Hazard Zone Maps have to be made for all communities and the local authorities have to implement Hazard Zones into the Land use Map.

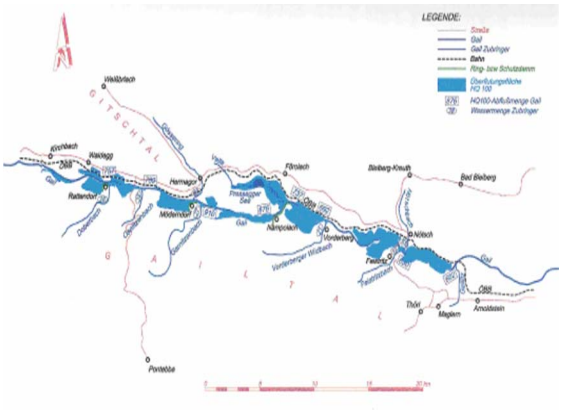

Fig. 4. Areas for possible water retention are mapped at the river catchment for developing local protection at the settlements (like dams, green signed) and the single objects (e.g. using stable materials, special waterproof materials or constructions) and areas for the “return of the rivers”. Green signs show local protections for settlements by dams. Ecology, without sacrificing safety.

Without doubt we have to accept and convey to the people, that like at technical countermeasures, at defensive measures there always will be a remaining risk too.

5. Nature Orientated Works / Activitive Works

Because the expectations people put in "near-nature techniques" are very high, it is absolutely necessary, that the experts on the field of torrent control and defense lay emphasis on the fact, that such measures have distinct limits:

（1）They cannot be used in torrents or torrent reaches, where debris flows may occur.
（2）They need definitely more room than mere technical countermeasures, therefore their application normally is very restricted in densely settled or urbanized areas.
（3）They cannot be used in river channels where the tractive force of the water is higher than the durability of the measurements of nature orientated works.

With enough room for control works they can be used for flood streams and bedload-transporting torrents or comparable torrent reaches.

Fig. 5. Example from Taiwan. Project Feng Chu. In the upper reach till down to the debris flow retarding basin, debris flows may occur. Natural orientated works only can be done on the slopes with soil bioengineering works but not in the torrent itself. Below the street, where the energy level is lowered, between the houses and at the agricultural area nature orientated works can be done – when you can acquire the space.

6. Orientated Targets

Additionally to the main goal "Protection of people and their activities" near-nature control techniques have to be orientated on

（1）the ecology of running waters especially in mountain streams
（2）the special situation of each catchment
（3）the natural channel morphology
（4）the natural stream bank and floodplain vegetation
（5）the special forms of natural or cultivated landscapes
（6）the demands of people for recreation
（7）the needs of preservation of endangered species

It is to emphasize that

（1）normally not all of these targets can be reached and that they can also exclude one another.

7. Short Remark on Mountain-Stream Ecology

Torrent control engineers know a lot about hydrology, runoff, bed load transport, debris flows, technical countermeasures etc., but they normally know little of mountain-stream ecology. But a basic knowledge of that is essential for a successful planning and implementing of "near-nature techniques". The ecosystem "mountain stream" is a principally open system without distinct boundaries to neighbored ecosystems.

Most important parts are:

（1）The water body,
（2）the channel including the banks,
（3）the hyporheic habitat, that is the gap system in the sediment of the channel bottom, connected with the groundwater

→ biotope

（1）the strips on both banks, which are influenced by the stream
（2）the plants and animals living there.

→ biocoenosis

→ ecosystem(as functional unit)

Fig. 6. shows schematically the interactions in a mountain-stream ecosystem.

8. Principles for "Nature Orientated Control Techmiques"

Torrent defense works in steep middle or upper reaches have certainly positive effects on the reaches downstream (also with regard to the ecosystems there), but normally they are and have to be above all technical constructions (consolidation dams, retention dams, debris-flow breakers etc.).

These principles therefore are formulated especially for regulation, channel and retention works in lower reaches, on alluvial fans and in redepositional reaches.

（1）With regard to mountain-stream ecology:

（a） Natural, "open" streambed.
（b） Different channel widths, channel depths, bank inclinations and cross sections,
（c） Natural bank development
（d） Use of natural building materials like stones and boulders, timber and plants
（e） Structuring the stream channel
（f） Planting structured streambank belts
（g） Structuring sediment and debris retention basins

（2）Additional with regard to mountain-stream fishes:

（a） Implementation of low-water level structures
（b） Deep enough pools in case of low-water runoff
（c） No barriers for fish migrations

（d） Installing fish passes (ladders) in case of too high check dams using „near-nature techniques“

（3）With regard to landscape protection:

（a） Design of control works according to similar natural streams or torrent reaches
（b） Planting or preserving shrub groups or tree groves near the channel use of natural building materials from the neighborhood as far as possible
（c） Necessary technical constructions built of concrete or in combination with steel elements should not be too dominating.
（d） Characteristic landscape elements, either natural or originating from cultivation by man, should be preserved or reconstructed.
（e） Preservation or reconstruction of natural or artificial secondary channels, e.g. for sawmills, irrigation or other purposes. Sometimes such secondary channels can be adapted also as fishways.
（f） Preservation of old defense works of historical value Torrent defense works of historical value should be preserved as a sort of cultural heritage.

（4）With regard to recreation necessities:

（a） Installing recreation facilities like walking paths and sitting places including information boards on the special mountain stream environment and control measures.
（b） Implementation of water playgrounds for children near and in the streambed (for that special purpose streambed adaptions with regard to children's safety are necessary).

（5）With regard to wildlife preservation:

Preserving wildlife habitats of endangered species sometimes natural streambeds and areas in the neighborhood are habitats for endangered plant or animal species. Control works should avoid such sites or try to reduce negative impacts as far as possible. Additionally it can be tried to enhance the conditions of endangered species by the implementation of special habitat structures and microsites. People should be kept off by densely planted brush belts or fences from such sites.

9. Some Examples (for Nature Orientated Works)

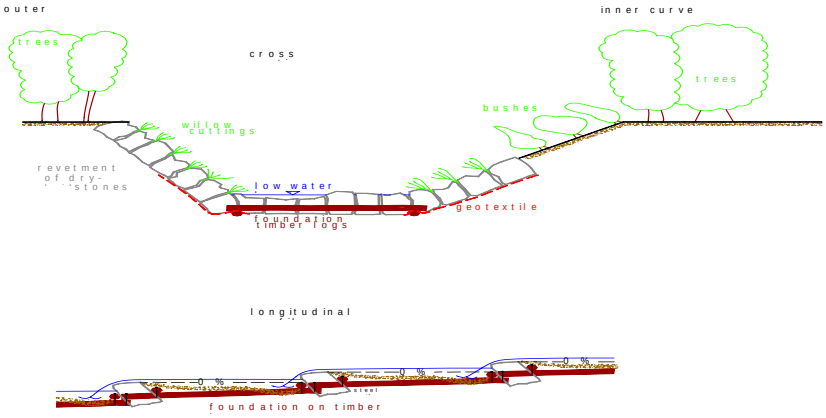

Fig. 7. Near-nature channelwork for flood streams and bedload – transporting torrents. Low sills of boulders and large stones, founded on and fixed by timber logs, nailed together. Revetments of dry-laid stones, at the lower half underlaid by a geotextile to prevent outwash of fine material

Fig. 8. and Fig. 9. Channelworks constructed after the method shown in Fig. 7. after some years with low and middle runoff.

Remarks on nature orientation:

（1） Stream bottom remains natural and the hyporheic habitat intact.
（2） Use of natural building materials
（3） The banks are structured by stones, but are not left natural
（4） Concentration of low-water runoff by irregular sill crowns
（5） Different currents and water depths (step-pool-structure)
（6） Sills can be jumped by fish
（7） Streambank vegetation of planted and natural origin, but not dense enough
（8） Good oxygen intake by the water-air-mixture resulting from overfalling water

Fig. 10. Torrent reach with concrete sills (covered by sediment) and dry-laid stone crowns, fixed by steel cables (upstream the sills, therefore not to be seen), the bank protection is done by different soil-bioengineering methods, just after implementation

Remarks on nature orientation:

（1） Stream bottom remains natural and the hyporheic habitat intact
（2） Use of natural building materials (stones, timber, plants)
（3） Technical defense measures not visible

Fig. 11. The same reach 2 years later with flood runoff.

Additional remarks on nature orientation:

（1） Dense streambank vegetation resulting from soil liveengineering techniques
（2） Step-pool-structure

Fig. 12. Channelwork controlling a small stream in a settled area. The stream bottom is fixed by low sills as shown in Fig. 2., the banks are protected by walls made of dry-laid stones.

Fig. 13. The same reach only 1 year later with high-flood runoff.

Remarks on nature orientation:

（1） Use of natural building materials (stones, timber, willow cuttings)
（2） Structuring the bottom by wooden piles and small tree stumps
（3） Different current patterns
（4） Good fish habitat
（5） Unnatural steep stone walls on both banks, due to the restrained possibilities in a settled area

Additional remarks on nature orientation:

（1） Dense streambank vegetation by fast-growing willows (Salix sp.)

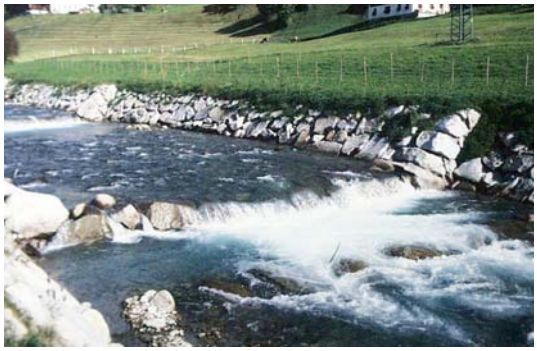

Fig. 14. Control works in a large bed-load transporting stream by sills made of dry-laid stones concrete foundation and fixed by steel anchors and by low revetments made of dry-laid stones.

Remarks on nature orientation:

（1） Different currents and water depths
（2） Good oxygen intake in the pools downstream the sills
（3） Sills can be jumped by fish
（4） Good fish habitat and spawning sites
（5） Absence of streambank vegetation

Fig. 15. Ramp of dry-laid stones as alternative to a dam or sill in a large flood stream.

Remarks on nature orientation:

（1） Use of natural materials
（2） Good intake of oxygen
（3） The ramp is no barrier for fish migration
（4） Poor streambank vegetation without trees
（5） Elements like this ramp are unnatural in case of floodplain streams

Fig. 16. Debris retention basin with special outlet construction (beam dam) just finished.

Remarks on nature orientation:

（1） The technical outlet construction is not dominating and additionally covered by soil and stones as far as possible
（2） The outlet opening reaches down to the stream bottom and therefore is no barrier or fish migration
（3） The basin bottom is structured by wooden piles, boulders, stone heaps and tree stumps
（4） Use of natural building materials on both sides of the outlet (earth, stones, willow cuttings)
（5） The basin is left to natural development

Fig. 17. The above debris retention basin is by-passed by a channel with water for running a sawmill The channel was reconstructed using dry-laid stones and timber logs as foundation.

Remarks on nature orientation:

（1） Use of natural building materials
（2） The channel is constructed in form of a fish pass
（3） Good intake of oxygen
（4） Streambank vegetation just started, should be supplemented.

Fig. 18. and Fig. 19. Debris retention basin shortly after excavation and 5 years later. (Southern Tyrol, Italy)

Remarks on nature orientation:

（1） Structuring the basin by a small channel and two ponds
（2） Creating a new habitat for stillwater and floodplain species
（3） The basin bank slopes have been left unprotected
（4） The banks has been left bare, resulting in a dense natural floodplain vegetation
（5） Landscape improvement of the surrounding intensively agricultural used area
（6） Only the outlet dam at the lower end of the basin is a technical construction

Fig. 20. and Fig. 21. The “Großache” a small river in the Tyrol. Widening up the river bed causes much more diversity and space for flood retention.

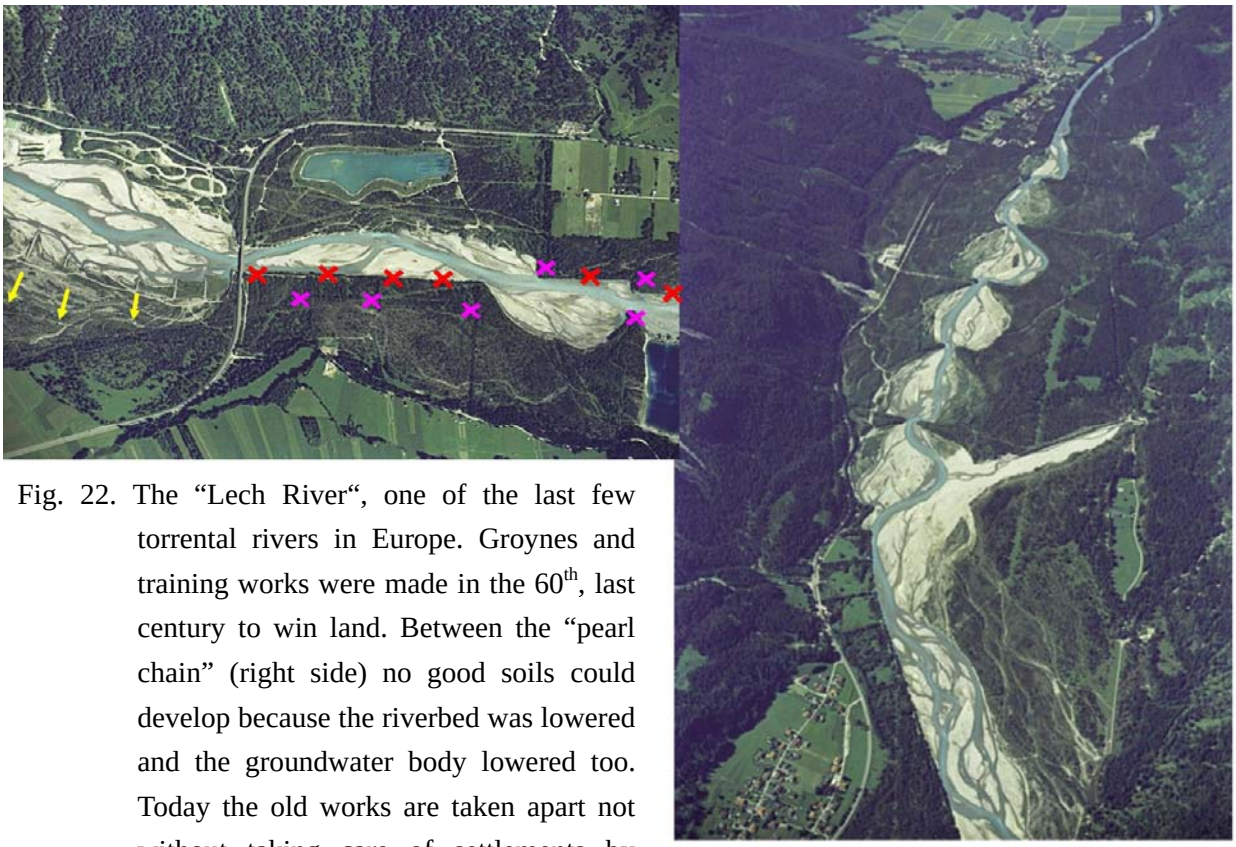

Fig. 22. The “Lech River“, one of the last few torrental rivers in Europe. Groynes and training works were made in the 60th, last century to win land. Between the “pearl chain” (right side) no good soils could develop because the riverbed was lowered and the groundwater body lowered too. Today the old works are taken apart not without taking care of settlements by other measures and giving bed load.

10. New Principle of Law in Austria (since 1990)

Because of urgent public demands the Austrian law for affairs of water was changed in 1990. Until that time there was just a section in this law about "keeping the water clean" and about "protection of water". Now the authorities has to check, if measures in the riverbed or nearby there or at the groundwater body are against interests of water, soil, animals, plants – against interests of nature. Since this novel of this law ecological measures also can be paid with money from public founds. This is mentioned, because in former times it was nearly impossible to acquire land for nature orientated works.

11. The European Water Frame Directive (WFD)

The EU Water Framework Directive is a bold and forward-looking instrument that will have far reaching consequences for future management of water and aquatic ecosystems throughout Europe. The central feature of the WFD is the development of integrated river basin management plans. These plans will be instrumental in ensuring the environmental objective of the WFD, "good water status", is achieved and maintained for all Community waters by 2015.

11.1 Five elements for effective integrated river basin planning

Five key cross-cutting issues need to be systematically considered for the different tasks to be performed during the river basin planning process, e.g. defining river basin districts, identifying key water management issues, assessing the most cost-effective set of measures for achieving objectives or developing monitoring programmes.

（1）Integration between organisations, economic sectors and disciplines dealing with water management issues is required for ensuring efficient and cost-effective river basin planning. This is especially relevant for international river basins. Also, other EU legislation, policy and financial instruments are to be integrated with water policy to remove or minimise obstacles to sustainable water management.

（2）The river basin is clearly recognised as the basic planning scale for water management measures. The great diversity in river basin sizes means approaches suitable to one location are not automatically transferable elsewhere, although the same basic planning principles must apply. Coherence is required between the processes developed at different spatial scales, i.e. reconciling top down and bottom up approaches to ensure environmental objectives are effectively met.

（3）Timing of implementation is considered as critical. Deadlines for achieving the objectives of the WFD are extremely challenging. But they must not be seen as a step-by-step timetable for implementation as many tasks will effectively be required before such deadlines. A general lesson on timing? Better start implementing early but imperfectly.

（4）Information, consultation and participation of the public and stakeholders are key elements of the process that will lead to successful river basin planning. Provision of transparent and accessible information, together with genuine opportunities for participation in planning and decision-making, should be prioritised from the start. Participation needs to be adapted to the appropriate scale, target groups and activities, and managed carefully to ensure expectations from all sides are clear and can be fulfilled.

（5）Capacity among all relevant actors needs to be maximised. Capacity building, starting with awareness

raising, is required for officials, planners and administrators, but also for economic sectors, local authorities and NGOs. Allocating adequate financial and human resources to capacity building and participation process will be key to implementing the WFD in particular for countries of Central and Eastern Europe future members of the EU.

12. Concluding Remarks

(Again) During the last decades in modern and high developed societies the environmental movement increased. Maybe this is a normal reaction of “mistakes” that have been done in the past. It is obviously, that when we are looking back from 2004, we have an other point of view now, we have a new aim – taking care of the environment more than before because we have the possibility and the need to do.

Protection measures at flood, torrent and erosion control always have the first aim to make life and settlement safe when they are endangered by natural hazards. Modern engineers have to be able to combine technical, ecological (and economical) needs. But the logical and human demand of being safe and having intact nature around should not lead to a reduced level of security that just seems to be safe.

Natural orientated measurements on slopes, in torrents, torrential rivers and rivers at the lowlands should be perfect at the right place. It is one of the most important features, that a modern engineer that works on the item of natural hazards, learns from the nature and draws the right conclusions for the safety of the people – and the sake of the nature.

Nature orientated control techniques are - without doubt - of rapidly growing importance because of urgent public demands on the one hand; on the other hand their possibilities and limits are tested each year on different sites in many countries. For the future an intensified exchange of experiences with such techniques is necessary to learn about their functional limits with the goal of further progress on that field.

From my point of view Taiwan with its natural equipment of climate, geology and biology has a good situation for these works at average conditions. The extremes like heavy precipitation at Typhoons (maybe combined with landslides caused by earthquakes) lead to high requirements to the natural orientated working engineer.