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"Partnerships for a Safer World in the 21st Century"

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Building a Culture of Prevention

VAW
Laboratory of Hydraulics,
Hydrology and Glaciology
of the Swiss Federal Institute
of Technology, Zurich

Coping study on

DISASTER RESILIENT INFRASTRUCTURE

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"Partnerships for a safer world in the 21st century"

UNITED NATIONS

PREFACE

In December 1998 an agreement was signed to provide support for the organization of IDNDR Program Forum to be held in July 1999 and its preparatory process through undertaking a coping study on the theme *Disaster Resilient Infrastructure* by Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie **(VAW)** of ETH Zurich within the project "Coping Studies on Research Needs for Future Disaster Reduction". These coping studies are implemented and coordinated by the Graduate Institute of International Studies, Geneva, the Programme for the Study of International Organizations (HEI-PSIO).

VAW is doing research only in some fields of natural hazards i.e. floods, debris flow, impulse waves and ice avalanches. Therefore, it was necessary to find partners to contribute to this report. Fortunately it was possible to find experts in each field of natura! hazard that were willing to write a chapter of this report. I take this opportunity to thank all authors for their valuable conmbutions. **A** detailed list of all authors **is** provided.

To contribute to the coping study was a chalienge. It is not easy to summarize the essentials on such limited space. And if the report gets too voluminous it would be too difficult tc read. 1 hope that the right equilibrium was found and this report introduces the reader on the main problems, **risks,** but also research needs and necessary activities to be taken in relation to natural hazards.

I want to thank Dr. Warner, Director of PIIO, the project coordinator for the excellent cooperation and Dr. Hager for having coordinated as a project head.

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GENERAL REMARK AND SUMMARY

H.-E. Minor

Economic losses attributable to natural hazards rise steadily as the figures of Munich Reensurance demonstrate. And eacn year a notable number of persons are killed or displaced at least for some time from their home areas. There are several reasons for the increase of impact by natural hazards:

- *Extension of settlements* including the corresponding infrastructure and productive plants is continuing. Not only the growing number of people **is** a reason but also the steady improvement of the built environment. Globalization and the pronounced division of labor in world economy will add even more in the future.
- There is and will be *more infrastructure* in the future that can be damaged; its construction cost is steadily increasing.
- Human activities with its settlements and infrastructure spread into endangered areas sometimes brcause no other space is available. This is convenient just on a short sight. *Construction costs* at flood plains for example are lower than on hilly ground. Since floods occur not every year, larger floods more than five years ago are normaly forgotten.
- Sports-activities and *tourism* also push into more extreme areas and add to the necessary infrastructure.

All these structures are exposed to a high **risk** but at the same time they are expected to withstand disastrous impacts during natural hazards. This is not always possible. Man must realize that *100% safety does not exist,* especially not if structures are exposed consciously to natural hazard. They cannot be made safe against all possible impacts of natural hazards. In some cases it is simply not possible because of lack of technical means while it would be much too expensive in other situations.

Another approach is to define *hazard zones.* In the most critical zones with a high hazard potential construction could be prohibited, in the second zone with a moderate potential hazard, prescriptions should be made to armour structure against the natural hazard, and in a third zone owners have to be informed about existing hazard. Additionally it is essential to build up a *second line of defence* in case the first defense line fails. Needless to state that a warning system as well as rescue measures have to be installed. The warning system is then effective provided real-time-prediction is possible and the *rescue measures* are effective if extensive training has been carried out for specific hazards.

The various natural hazards have different character because they are governed by different physical processes. Accordingly, the methods of *hazard intervention* also differ. Table 0.1 attempts to demonstrate these differences and at the same time intends to show the possibilities of intervention. Three zones have been distinguished:

- Origin or source of hazard,
- Propagation or spreading area, and
- Zone of impact.

For extreme natural hazards, structures are essentially not able to resist, while other can be dealt with by a correct design. For many natural hazards it is nearly impossible to intervene at the source, for some, however, this approach is feasible such as landslides. Then, of course, this should be the first line of activity. As can be seen from Table 0.1 intervening in the propagation/spreading area is effective for many natural hazards.

In addition to the possible actions to be taken as listed in Table 0.1, consequent *regional planning* with definition of hazard zones would reduce considerably the impact of natural hazards to infrastructure *Hazard zoning* should be defined not only for one natural hazard scenario, but all natural hazards of a site should be investigated at the same time define the combined **risk** of endangered areas.

In this context it must be mentioned that different hazards are treated separately by the corresponding specialist. However, two or more natural hazards may ***interact*** and the experts have to come up with a common definition of solution. **Future** research has to take this aspect also into account.

The different chapters of this report aim to present the specific research needs in more detail or define the necessary activities *to* be carried out to make infrastructure more disaster resilient, as regarded by the authors.

Table 1 Possibilities of hazard intervention

Hazard / Zone	① wind	② snow avalanches	③ ice avalanches	④ rockfall	⑤a landslides	⑤b debris flow	⑥ impulse wave:	⑦ earthquake	⑧ forest fires	⑨ floods
Origin or source	none	supporting structures, artificial release of avalanches, silviculture, reforestation	none	limited	slope geometry, retaining structures, slope reinforcement, drainage. Large, steep slopes cannot be stabilized	check dams in torrents and scour measures, as for landslide	stabilize slides, draw down reservoir, control slide velocity	none		none
Propagation spreading area	little, consider vortex shedding	deviation dams, retaining dams, retarding structures	structures to divert avalanche away from vulnearable structures	various structures to hold brick rockfall	none	protection dams to keep debris flow from vaiunerable structures Japanese trap	drawdown of reservoir	none		Retention basins, flood plain diversion structures, reduce sediment and drift wood supply
Zone of impact	apply state of the art design	shed structures	very limited	rock sheds	structures are essentially not able to resist thrust by landslide	see landslides	very limited	adequate design of structures, but also of infrastructure		increase river capacity, flood dykes, more space for river, increase erosion resistance