Overall Conclusions and Recommendations for a Practical Training Programme

Overall Conclusions

In China, landslides cause an estimated 15 billion USD in economic losses and about 150 deaths annually, exceeding the total annual losses due to earthquakes. Most landslides found over the last 40 years have been concentrated in the provinces of Sichuan, Yunnan, Guizhou, Xizang, Shaanxi, Fujian, Hunan, Hubei, and Taiwan. In other provinces, landslides develop less often than in the provinces mentioned above. Most landslides in these areas are triggered by heavy rain and/or melting snow, major earthquakes, and human activities. Occasionally, large hazardous landslide dams have been formed, particularly in the Hengduan mountain area of southwestern China. Financial investment in development projects in mountain areas, such as road and reservoir construction and exploitation of mineral resources, have accelerated landslides and increased landslide damage. The impacts of landslides on development are great and, apparently, growing.

Landslide hazard zonation maps are essential for assessing potential damage and quantifying risks and could be used by planners and decision-makers in planned development areas in hill and mountain countries. Scientific forecasting for landslide prediction and early warning also depends to a great extent on landslide hazard zonation maps. The content, method, and scale of landslide mapping depend, above

all, on the map's purpose. Landslide susceptibility maps or hazard zonation maps are generally more useful for planners and decision-makers than for landslide inventory maps.

The analysis of aerial photography is a quicker and more valuable technique for identifying landslides than satellite remote sensing, because it has a relatively large scale and provides a three-dimensional overview of the important geomorphic features. Therefore, landslides are more effectively mapped with conventional ground techniques supported possibly by low-level aerial photography.

Most conventional GIS techniques for landslide mapping are based on 'map overlaying', which only allows for the comparison of different maps on the same location and scale by placing one on top of the other and using the criteria for landslide hazard assessment and mapping.

Landslide damage has been effectively reduced by avoiding hazards or reducing damage potential. This is primarily achieved by four mitigative approaches: (1) avoiding landslides (2) preventing destabilisation of potential landslides and slopes, (3) using physical measures to prevent or control landslides, and (4) development of landslide prediction and warning systems. Not a single method for managing landslides or unstable terrain, but a variety of techniques is needed by the engineer. One of the most significant landslide and debris flow prediction and warning systems in China has been developed on the middle and upper reaches of the Changjiang River (Yangtze River) by the Changjiang River Planning Committee in cooperation with the Institute of Mountain Hazards and Environment.

The natural damming of rivers by landslides is a significant hazard in many mountain areas of China, and it is particularly common in the high rugged Hengduan mountains of southwestern China. The vast majority of landslide dams are formed by rock and earth slumps and slides. Assessment of upstream and downstream floods is essential for landslide dams. Such estimates require knowledge of the height of the dam crest, rates of streamflow into the dam lake, rates of seepage through or beneath the dam, and information on the topography upstream from the dam. Downstream floods can be estimated by specific empirical equations. In order to prevent dam failure and subsequent flooding, spillways are the most simple and common methods. Pipes, tunnels, outlets, and diversions have also been used to prevent dam failure and control discharge from landslide-dam lakes.

Recommendations for a Practical Training Programme

To achieve a dramatic reduction in landslide disasters there is a strong need to develop skills in landslide mapping, hazard zonation, control, and prediction. For this purpose, a practical training programme is proposed as follows.

1) The training programme is primarily designed to integrate the training course with field experience by

   - visits to problem sites, development of programmes to solve the problems, and field experience;
   - lectures/talks by experienced programme planners and project directors/managers about their experiences in project planning and project implementation; and
   - on-the-job training at possible project sites.

2) The main item of training may be any of the following.

   - Use of aerial-photographs for landslide identification
   - Landslide hazard zonation and mapping
   - Uses of landslide maps for hazard mitigation
   - Landslide and debris flow prediction, i.e.,
     - place prediction,
     - real time prediction, and
     - prediction of extent of landslide motion.

- Landslide disaster assessment
- Landslide hazard mitigation
    - Engineering control works
    - Bioengineering stabilisation
    - Non-technical methods
- Social science and interdisciplinary aspects of landslides
- Planning measures and landslides
- Land use and landslides

3) Visits and study tours to different landslide control project sites

The trainees will benefit from seeing different approved practices and from hearing lectures and talks by experienced programme planners and project directors/managers about their experiences in project planning and project implementation.

4) On-the-job training at possible project sites

Every trainee should undergo an on-the-job training programme in the following fields.

- Landslide mapping and hazard zonation
- Landslide monitoring and observation
- Moving debris flow, prediction, and warning system
- Planning and control works for landslides