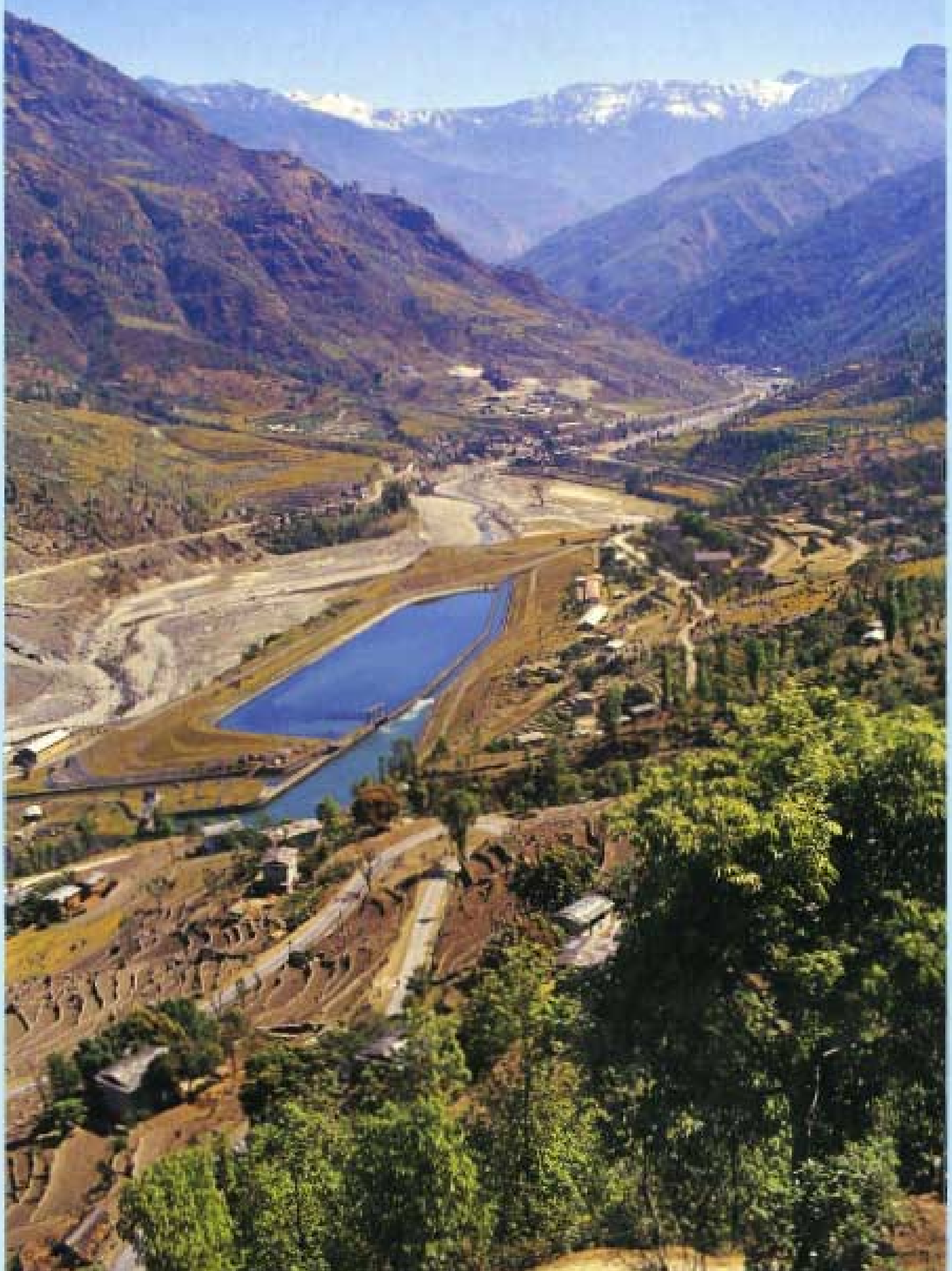
MOUNTAIN RISK ENGINEERING HANDBOOK

APPLICATIONS: Part II



ICIMOD

Principal Editors
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Cover Photographs : B. Deoja

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Arniko Highway, Nepal, March 1991.

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PREFACE

The progressive and effective development of mountain communities through an integrated approach is the principal perspective in ICIMOD's mandate. Infrastructural establishment, therefore, being one of the primary needs for development, has to be carried out, taking into consideration this integrated, holistic perspective. Notwithstanding, experiences indicate that integration of essential modern development technologies with effective and sustainable resource management has not received sufficient attention.

In the Hindu Kush-Himalayan (HKH) Region, failures and washouts of roads, irrigation canals, and power plants have resulted in considerable losses of life and property. In addition, the vulnerability of mountain ecosystems has been exacerbated by the techniques applied in establishing infrastructure. Development with conservation is, therefore, essential.

The impacts of artificial structures and human interventions on mountain slopes can only be understood adequately within the context of a broader-based knowledge and understanding of the inherent properties of the materials constituting the mountains themselves and the dynamics that influence the surface and sub-surface processes and environments. Traditional civil engineering education and practices are not adequate to fulfill this requirement.

Geology, the science of the earth, can help to provide the requisite understanding so that civil engineers will have a clear picture of what can be done to keep a structure in place throughout its expected life. This knowledge, however, is only useful to the engineer provided the time horizon, material, and process characterisation provided by geology are adequately scaled, quantitatively ascertained, and clearly presented to facilitate their direct input into civil engineering analysis and design.

The application of engineering-geological inputs is not new in the case of major projects such as dams, tunnels, and mines, but in the case of linear infrastructure, such as roads and canals, scant attention has been paid to engineering-geological inputs, especially in the developing countries. As the pressure of population increases in the mountains, there will be a need for more roads and canals throughout these areas. The additional impacts caused by their construction are bound to accelerate natural destabilization and processes caused by people will add to the forces of nature. This presents us with a choice, i.e., people as a positive force, friendly to nature, or as a negative force that is hostile to nature.

The devegetation and deforestation associated with infrastructural establishment have created an extremely important role for soil conservation, forestry, and ecology so that establishment of plantations and vegetation within the watershed areas that influence roads has become an integral part of normal engineering practice. Long-term, sustainable protection of mountain slopes influences infrastructural stability and, in this respect, plantations and vegetation are crucial because engineering solutions alone are neither cost-effective nor hospitable to mountain ecosystems.

Infrastructural development is no longer the domain of a single discipline, i.e., civil engineering, and mountain infrastructural engineering cannot be separated from a basic knowledge of the geology, environment, and other related disciplines. The Mountain Risk Engineering (MRE) Programme introduced by ICIMOD is a step forward in the process of the integration of various disciplines in order to induce the establishment of sustainable mountain infrastructural institutions.

This handbook is a synthesis of selected practical experiences and up-to-date literature, and its objective is to provide a working basis for training institutions and practising engineers and geologists involved in the development of infrastructure in mountainous areas, in general, and in the mountainous areas of developing countries, in particular.

The question arises, in the case of developing countries with low per capita income, of the additional costs incurred by MRE approaches. How much room is realistically available in fragile mountain terrains for site selection? how compatible is the concern for resource conservation over the long term with the immediate needs of a subsistence economy? and so on.

A comprehensive response to all of these concerns is outside the scope of this Handbook. Nevertheless, experience has shown that there is ample room for the minimisation of hazards and that the cost of rehabilitating failed infrastructures will easily offset the one or two per cent of additional expenditure needed for proper investigation and analysis. In addition, the benefits accruing from soil loss reduction and reduction in the loss of productive land, caused by hazards incurred by infrastructures designed within a narrow framework, are additional bonuses.

This handbook is a combination, of an earlier draft version and incorporates inputs and comments received from several resource persons and institutions, both in the Region itself and from other parts of the world. For this reason, and because of the limited time period permitted for its completion, the general spelling style has, by and large, had to follow the most common usage prevailing in the case of each term and word. Had we standardised to one of the principal dictionary styles (Websters or Oxford) the document would not have been completed within the time-frame required, given the facilities available. In short, the amount of material to be edited, and the degree of editing prohibited by this, is a fact regretted by the editor.

The complete MRE approach has been used to conduct a feasibility study for, and to design a road project in, Nepal. Obviously, there will be more inputs of this nature in future and the Handbook will need revision from time to time until Mountain Risk Engineering establishes itself as a discipline in its own right and until it is fully institutionalised within the infrastructural agencies of the developing mountain nations. In this respect, an Expert Group Meeting, International Consultative Meeting, Pilot Training, and individual visits from academicians, policy-makers, and donor agencies have served to indicate the sizeable degree of enthusiasm already existing as a result of the establishment of the Mountain Risk Engineering Project.

Thanks are due to all those who helped us to achieve this task; those who inspired ICIMOD and who became inspired by ICIMOD about Mountain Risk Engineering. The mountains, which remain seemingly silent, but nonetheless dynamic, will give more to mountain inhabitants than they will receive provided we handle them with care.

These mountains, seemingly silent but truly dynamic, have a lot to give to the people of the mountains as well as to the people of the plains provided we start to understand and appreciate them. MRE, thus, begins this process.

Birendra Deoja

MRE Project Coordinator

ACKNOWLEDGEMENTS

This handbook on Mountain Risk Engineering (MRE) is the product of the contributions of many people. I am grateful to all of them. In particular, I with to record my deep appreciation and thanks to Dr. Colin Rosser, the Previous Director, for the initiation of Mountain Risk Engineering (MRE) work at ICIMOD, and Dr. E. F. Tacke, the current Director, for his encouragement and untiring support throughout the work on the completion of MRE Phase I and for initiating MRE Phase II which has resulted in the first full-scale publication of this Handbook.

The generous financial support of the Commission of the European Economic Community (EEC), for Phase I, and the Swiss Development Cooperation (SDC) and German Technical Assistance (GTZ), for Phase II, are gratefully acknowledged. This is indicative of their growing concern for the deteriorating mountain environment and the increasing impoverishment of its inhabitants.

Alexis Wagner of ITECO International, Switzerland, Dr. Mahesh Banskota, Chief Programme Coordinator, Mr. Surendra Shrestha, the Chief Administrator, and Dr. M. Abdullah, the former Head of the Mountain Infrastructure and Technology Division of ICIMOD, assisted in the development of the project proposal and also helped in many ways in the completion of this work. Similarly, N.D. Sharma, Director General of the Department of Roads, HMG, Nepal provided his enthusiastic support and guidance. There were also several institutions that have been supportive throughout the whole period and a few of these are: The Department of Roads, HMG, Nepal; ITECO International, Switzerland; The University of Roorkee, India; The Transport and Road Research Laboratory (TRRL), U.K.; The Public Works' Department, Bhutan; The Ministry of Communication, NWFP, Pakistan; The Chinese Academy of Sciences, Beijing; Tribhuvan University, Kirtipur, Kathmandu; The Department of Mines and Geology, HMG, Nepal; and ITECO-Nepal, Kathmandu.

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The Handbook would never have been completed, within the short period of time given, without the untiring efforts of its team of contributors, Dr. R. Anbalagan, Dr. Dominique Chapellier, Dr. M. Dhital, Tom Heah, K.C. Manandhar, Dr. Tej Partap, Urs Schaffner, Dr. Bhawani Singh, Bhaskar Thapa, and Alexis Wagner.

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Greta Rana, the editor of ICIMOD, undertook the task of editing this voluminous manuscript in such a short period of time and made our task easier in preparing this manuscript which is now lucid and readable. Archana Karki, assistant editor, ICIMOD, was of invaluable assistance during the compilation of different sections.

The figures for the handbook have been painstakingly prepared by three excellent draughtsmen, Bipin Ghimire, P.B. Shakya, and S. B. Phainju, and the initial entering of the topic index was carried out by Sujit Thapa and Sarit Rana.

There are many others who have given their support both within and outside ICIMOD and, although they have not been listed here because of paucity of space, they are gratefully and duly acknowledged. Finally, we are grateful to all those authors whose generous contributions have made it possible to bring out this Handbook on Mountain Risk Engineering.

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FOREWORD

Infrastructural development in the Hindu Kush-Himalayan Region is a formidable task with considerable problems caused by washouts and failures resulting from landslides, erosion, and gullying. Such problems are, to a significant extent, triggered by faulty planning and designing of mountain infrastructure which also have ramifications on their construction and maintenance. These problems are compounded by mass movements caused by natural processes, deforestation, and other human interventions. They constitute a huge challenge for the building and maintenance of sound physical infrastructure. Therefore, there is an urgent need to develop guidelines for the construction of infrastructure that is ecologically stable and economically viable. It is in this context that the mountain risk engineering programme was started in January 1988 with financial support from the European Economic Community (EEC).

The first draft manual on Training in Mountain Risk Engineering was tested during a nine week pilot training programme from February-April 1989. Twenty participants, mainly engineers and geologists from Bhutan, China, Nepal, and Pakistan, participated in the training sessions. Subsequently the manual was revised and put into folder form for convenient distribution. The preparation of the manual was undertaken by ICIMOD staff in close collaboration with short-term professional inputs from Europe and the Regional countries.

The manual was sent to international experts in this field for their comments. This was followed by the organisation of an International Consultative Meeting on Mountain Risk Engineering in February 1990 in Kathmandu. Some 40 experts, representing government agencies, consultants, donor agencies, and university professors, participated and commented on the content and utility of the manual. There was a general consensus that the MRE Manual was an extremely useful document in the context of providing guidance for sound infrastructural development and that its wider application is urgently needed. It has already been used by the Department of Roads and several foreign consultants in Nepal. As a follow up to the recommendation of the Consultative Meeting, the Swiss Development Cooperation (SDC) and the German Technical Cooperation Agency (GTZ) were approached for funding for the preparation of this Handbook for wider dissemination and for the organisation of an eight week training programme in Kathmandu on Mountain Risk Engineering; and this they have generously supported.

This Handbook is being produced in two parts and will provide useful reference materials to field engineers engaged in building ecologically and economically sound infrastructure in the mountains. It can also provide useful course material for students who are being trained as civil engineers and geologists.

Finally, Mr. Birendra Deoja, Coordinator of this activity deserves special mention, along with his colleagues, who worked extremely hard to bring out this very useful Handbook on Mountain Risk Engineering.

Dr. E. F. Tacke

Director

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