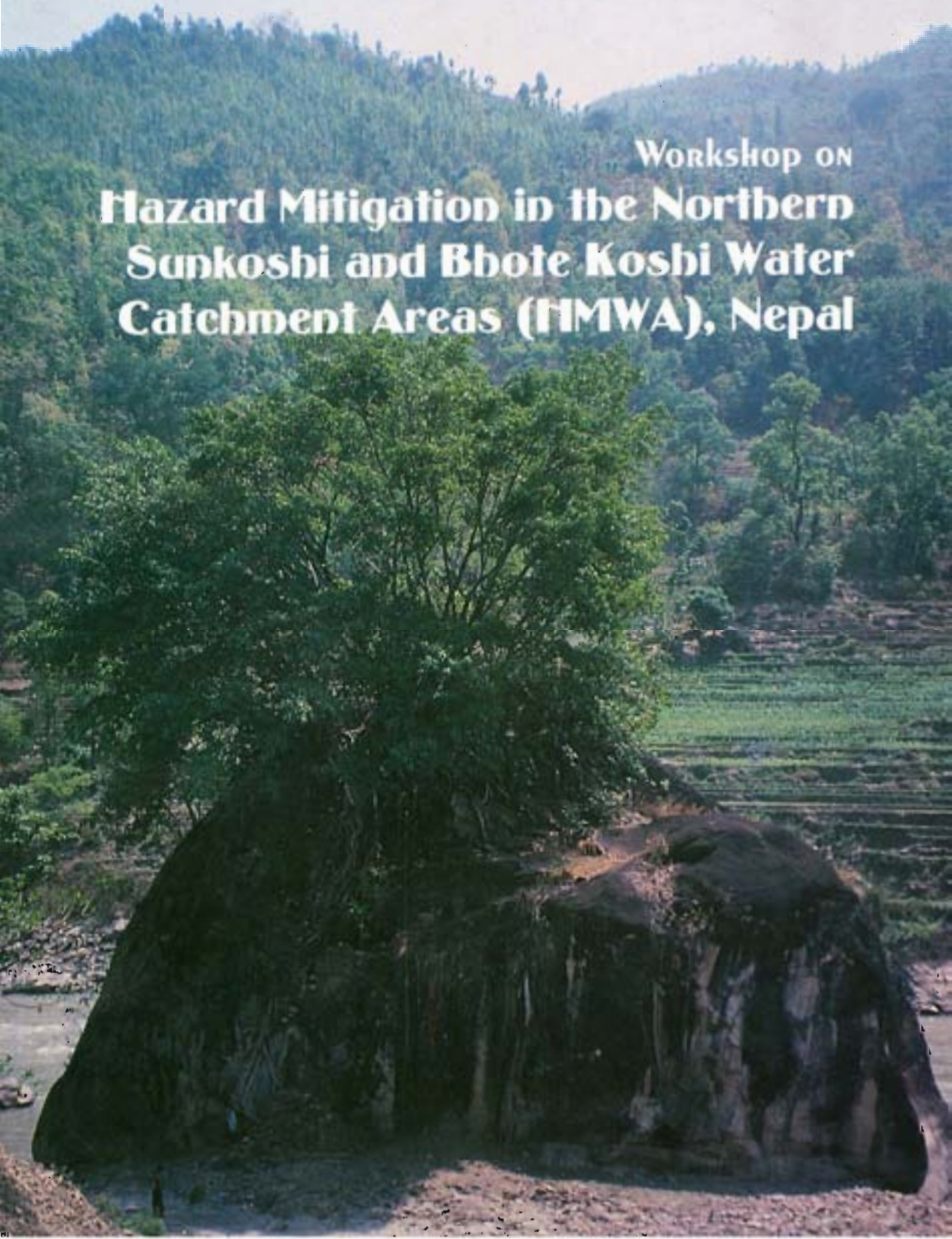
ICIMOD

Workshop on

Hazard Mitigation in the Northern Sunkoshi and Bhote Koshi Water Catchment Areas (HMWA), Nepal



Workshop on Hazard Mitigation in the Northern Sunkoshi and Bhote Koshi Water Catchment Areas (HMWA), Nepal

Organised by
Nepal-Switzerland Cooperation Project
International Centre for Integrated Mountain Development

8-10 May, 1996
Kathmandu

Photographs

Cover: Panch Kanya Rock (Hanuman boulder) near Balephi: S. R. Chalise
Back: Landslide at Lamosangu: G. Rana
Text: G. Rana

Published by
International Centre for Integrated Mountain Development
GPO Box 3226
Kathmandu, Nepal

Typesetting at ICIMOD Publications' Unit

Foreword

Mountains all over the world are identified with hazards, and nowhere is that more critical than in the Hindu Kush-Himalayas, the youngest geological formation in the world. Landslides and floods have been common throughout the region since time immemorial. The traditional response mechanisms of the mountain people have been the building of villages in stable upland areas and trails mostly following the ridges and upper slopes of the hills.

Population growth and scarcity of fertile lands on stable geological formations have forced many people to work and live in more unstable areas, increasing the risks of suffering from these natural calamities. In addition, the building of roads and other infrastructure is causing new man-made landslides to occur.

The subject of hazard mitigation is very mountain-specific and therefore of prime interest to ICIMOD's mandate. Over the past ten years, the centre has addressed hazard mitigation from different perspectives, with a major emphasis on mountain risk engineering and landslide hazard management. Three projects in these fields are presently being implemented by ICIMOD.

The present document reports on a workshop that discussed the results of a two-year study on Hazard Mitigation in the Northern Sunkoshi and Bhote Koshi Water Catchment Areas, which was carried out by ITECO, Switzerland, under a separate agreement with the Swiss Programme's contribution to the UN's International Decade on Natural Disaster Reduction (IDNDR) Programme. ICIMOD, under its Mountain Natural Resources' (MNR) Programme, is very pleased to have been associated with this project by providing the secretariat of its steering committee and hosting the workshop and organising the field trip. The project has made an important breakthrough in conventional thinking about glacial deposits and geomorphological processes in the hills of Nepal. This may have important repercussions on planning roads, dams, and other infrastructure that needs a sound foundation. The very lively discussions that took place, and of which this report can only be a summarised representation, showed that the subject is of considerable interest to scientists and development planners from many different backgounds and institutions. It was also made clear that the findings and issues raised were not only relevant to the study area but also to other parts of the Hindu Kush-Himalayas, including the upstream area in the Tibetan Autonomous Region of China.

ICIMOD is very grateful to the Swiss Development Cooperation for the financial support received to be associated with this project and to Mr. A. Wagner, Dr. A. Pugin, Dr. B.N. Upreti, and their colleagues in the study team from Switzerland and Nepal for the scientific outcome of their studies and their strong commitment to ensure that the results be used for improving the capabilities of Nepalese institutions to plan and implement measures to mitigate landslides in Nepal; and to share this knowledge with other parts of the Hindu Kush-Himalayas.

Egbert Pelinck
Director General

Acknowledgements

The production of this workshop report is the result of the efforts of a number of people. Greta Rana wrote the report with the assistance of Anita Pandey and inputs from Veneeta Singha. The report is a comprehensive synthesis of their language rapporting and the inputs of the technical rapporters, S.R. Pant, V. Dangol, and A.N. Bhandari. Sushil Joshi is responsible for the layout. The workshop was coordinated by Professor Suresh Raj Chalise. Hopefully the report will justify the efforts of all those involved in its publication.

Abstract

The final workshop of the "Nepal-Switzerland Cooperation Project on Hazard Mitigation in Northern Sunkoshi and Bhote Koshi Water Catchment Areas" (HMWA) was held in ICIMOD from the 8th to the 10th of May 1996.

This project, which lasted for two and a half years, was implemented by ITECO Eng. Ltd, a Swiss company which has a long-term experience in the Himalayan region, particularly in Nepal, in collaboration with ICIMOD, ITECO-NP, and the Swiss National Service of Hydrology and Geology. It was funded by the International UNO Decade on the Prevention of Natural Catastrophes through the Swiss National Service of Hydrology and Geology and partly by the Swiss Development Cooperation. A Consulting Committee of HMG line agency representatives followed the work of the project.

The project carried out research on the fragile thick quaternary deposits of the Bhote Koshi and Upper Sunkoshi catchment areas, on geological and hazard mapping, and surveying specific instabilities damaging farmland and threatening the Arniko Highway. Design of small-scale engineering and bio-engineering measures for controlling these instabilities was also finalised. The project also included hydrological studies linked to debris flows and instabilities on specific streams and sites. Several teachers and graduates of the Department of Geology of Tribhuvan University, as well as other Nepalese professionals, were trained on-the-job on the above topics and, consequently, formed the survey team of the project. Six Swiss ex-patriates, e.g., geologists and geophysicists, a bioengineer, and hydrologists participated in the project as trainers and implementors.

As a result of the research, it was confirmed that the fragile and thick quaternary deposits were of glacial origin. Very deep glacial Paleo-valleys infilled by glacial or glacio-fluviatile sediments could be identified down to low altitudes thanks to the seismic reflection method, and confirmed the output of electrical soundings carried out earlier on the occasion of the Arniko Highway Project. Such Paleo-valleys are located below or besides the present riverbeds. The study of sediment exposures with typical glacial depositional features, the presence in deposits of pollens indicating a cold climate vegetation, and other findings are convergent facts indicating that the valleys were glaciated in the remote past. The Charnawati Rehabilitation Project as well as the HMWA project could also identify a typical till and thick glacial sediments in the Charnawati catchment area. It is, therefore, highly probable that other valleys in the northern hills were also glaciated at low altitudes during the same period.

Contents

Part One

INTRODUCTION TO THE WORKSHOP

The Workshop on Hazard Mitigation in the Northern Sunkoshi and Bhote Koshi Water Catchment Area took place at the ICIMOD headquarters in Kathmandu from the 8th to the 10th of May 1996, inclusive. The first day's sessions consisted of an inaugural session, followed by lectures by **Mr. Alexis Wagner** and **Dr. Andre Pugin** on the work carried out during the two and a half year project period. A project completion report was made available to the participants in draft form and examples of hazard maps of the area were displayed for their convenience. The second day was taken up by a field trip to the study area along the Arniko Highway (Dolalghat to Kodari).The third day was completely devoted to discussions of the findings of the project by two distinctly-focussed groups, presentation of group recommendations, and final discussions. The Workshop participants were able to reach a positive consensus concerning directions for the future in the context of the project's findings.Throughout, the Workshop did not confine itself within a rigid time framework in terms of delineating session periods, and this made it possible to concentrate on issues that participants deemed to be of critical importance. The Workshop Programme is given in Annex One and the names of participants in Annex Two.

DAY ONE: INAUGURAL SESSION

Welcome Address

This session was chaired by **Professor Suresh Raj Chalise** and opened with a welcoming address by **Mr. Egbert Pelinck**,Director General of ICIMOD. In his opening address, Mr. Pelinck stressed the importance of work on hazard mitigation, especially in a fragile environment like that of the Hindu Kush-Himalayas. He assured the participants of ICIMOD's interest in providing a forum for discussion and debate that would lead to measures to improve sustainable mountain development and the standards of living of mountain people. He wished the Workshop success and assured them that, even though he was not able to attend the workshop throughout, his interest in this topic was such that he would make every effort to join in the deliberations to the greatest extent possible.

Background to the Workshop

Mr. Alexis Wagner stated that this was the final workshop of the Nepal-Switzerland Cooperation Project on Hazard Mitigation in the Northern Sunkoshi and Bhote Koshi Water Catchment Areas carried

out by ITECO in collaboration with ICIMOD.He referred to the fact that a draft report had been prepared for use by the participants and that they were here to discuss the findings and analyse them. For this reason the forty-five participants invited included professionals from HMG line departments, scientists, representatives of development cooperation agencies, and practitioners from private companies. This would allow for comprehensive discussion and analysis of the project findings. The results of the project were to be presented by Dr. Andre Pugin during Session One, this would be followed by a discussion on Instabilities and Hazard Mapping in Glacial Deposits during Session Two, which would be conducted by Mr. Wagner himself. On the second day there would be a field trip along the Arniko Highway. During this field trip, the participants would examine glacial deposit exposures and landslides along the highway. Finally, on the last day, there would be group discussions in three groups (this was reduced on the final day to two groups, see Annex 3) to discuss the scientific aspects and practical issues that had arisen as a result of the project work. Conclusions and recommendations would be formulated by these groups and there would be a final discussion to arrive at coordinated recommendations from the workshop as a whole.

In giving the background to the project, Mr. Wagner stated that it had been implemented by ITECO Eng.LTD, a Swiss company that had acquired a great deal of experience in the Himalayan Region, particularly in Nepal. ITECO had worked with ICIMOD, ITECO/ Nepal, and the Swiss National Service of Hydrology and Geology.The Project was funded by the International Decade for Natural Disaster Reduction (IDNDR) of the United Nations (UN), the Swiss National Service of Hydrology and Geology, and partly by the Swiss Development Cooperation (SDC) as a contribution to the UN's IDNDR. A Steering Committee of HMG line agencies had guided the project work from its inception.

The project had carried out research on the fragile thick Quaternary deposits of the Bhote Koshi and Upper Sunkoshi catchment areas. Geological and hazard mapping and surveying of specific instabilities damaging farmland and threatening the Arniko Highway were carried out. Small-scale engineering and bio-engineering measures to control these instabilities had also been finalised. Hydrological studies linked to debris flows and instabilities on specific streams and sites had also been carried out. Several teachers and graduates from the Department of Geology of Tribhuvan University and a number of other professionals from related departments had received on-the-job training on the above topics, subsequently forming the project survey team. Along with these, six Swiss personnel (their disciplines

including geology, geophysics, bio-engineering, and hydrology) had participated in the project as trainers and implementors.

In July 1987, in this area, the monsoon rains were exceptionally strong and the rainfall events caused critical undermining of rivers and streams with undercutting of banks. Quaternary deposits were heavily saturated with water. Consequently, many landslides were triggered and heavy damage was caused by stream erosion. Many farms and long sections of road were affected.

In the area chosen for the project, about two kilometres of the Arniko Highway were washed out and one kilometre of the Lamosangu-Jiri road was heavily damaged and seriously threatened by landslides at the Charnawati River crossing. A bridge was swept away, disrupting traffic for a considerable period of time.

Investigations carried out by road rehabilitation projects revealed that most damage had occurred in areas where there was significant thickening in the Quaternary material on the banks or within the catchment and sub-catchment areas of the rivers and their tributaries. Water tables had risen in many areas and farmlands were subjected to sliding. The process was intensified due to environmental stress caused by inappropriate road construction and poor maintenance as well as the heavy floods. Specific features coming to light during the work being carried out were demonstrating factors not identified before in Nepal. Considering the damage suffered along the road corridors, it was assumed that damage must be substantial beyond them; in fact, this was observed in the Charnawati River's catchment area which is crossed by the Lamosangu-Jiri Road.The streamflow alteration during the 1987 flood for this small river alone was from 40m^3/sec to 160m^3/sec.

It was argued that, due to active deforestation, it could be expected that the condition of human settlements and land would deteriorate rapidly in the absence of mitigation measures, especially in the areas of fragile Quaternary deposits. In addition, the construction of another 10,000 kilometres of new roads is foreseen within the next 20 years; most of them being north-south link roads which will have to cut through fragile deposits. The nature of such deposits may be glacial, as inferred by investigations, and was to be discussed in more detail in the remainder of Session One and during the field studies. Therefore, a thorough knowledge of the geological, geotechnical, and sedimentological nature of the terrain was a *sine qua non* for the establishment of additional infrastructure.

The Nepal-Switzerland Project on Hazard Mitigation in the Northern Sunkoshi and Bhotekoshi Water Catchment Areas (HMWA) was commissioned on the basis of these considerations.The main

objectives were directed by the need to undertake complementary geological and geophysical research on the inferred glacial deposits. Accordingly, the detailed project objectives were the following.

1. To train Nepalese geologists to identify glacial deposits recently discovered, even at low altitudes, in the valleys of the Sunkoshi and Bhote Koshi rivers, as well as in the valleys of their tributaries and other rivers of the region.

2. To carry out geological, geomorphological, sedimentological, and geophysical research on the inferred glacial deposits and to train Nepalese geologists in the production of geological and hazard maps of the inferred glacial deposits.

3. To train a botanist and civil engineer in the above-mentioned stabilising techniques.

4. To conduct hydrological studies of the streams affecting the inferred glacial deposits and to train two Nepalese hydrologists on relevant hydrological methods.

Session One

Glacial Basin Analysis of the Northern Sunkoshi and Bhote Koshi Water Catchment Areas

Dr. Andre Pugin conducted this session. He described the findings of the project and discussed the glaciation and glacial deposits which were illustrated by figures. Among the figures were geological maps which gave a better understanding of the Quaternary deposits described. One of the figures indicated the locations of the major Quaternary deposits in the area.(Dr.Pugin noted that the draft report had been made available for the participants' reference.)

He believed that, as a result of the research, it was confirmed that the fragile and thick Quaternary deposits in the areas (which covered about 70sq.km.) were of glacial origin. Dr. Pugin referred to the identification of three glacial stages: namely, i) the Bahrabise Glacial Stage,the maximum extension limit being upstream from Bahrabise Bazaar near the confluence of the Bhote Koshi and the Khagdal *Khola;* ii) the Lamosangu Glacial Stage,the maximum extension limit of this stage being visible at Kilometre 80 on the Arniko Highway close to Lamosangu; and iii) the Balephi Glacial Stage, the maximum extension limit being at Kilometre 71, or a little downstream from there. Dr. Pugin briefly described the main deposits.

Very deep Paleo-valleys infilled with glacial or glacio-fluvial sediments could be identified down to an altitude of 700masl. This

was made possible by the use of the seismic reflection and refraction methods and confirmed the results of earlier electrical soundings carried out during the Arniko Highway Rehabilitation Project.The Paleo-valleys were found below or beside the current river beds. Study of sediment exposures with features typical of glacial deposits, the presence of pollen deposits indicating cold climate vegetation, and other findings; all of these suggested that the valleys were glaciated in the remote past.The Charnawati Rehabilitation Project too had identified typical glacial till and thick sediments in the Charnawati catchment area. It was highly probable, therefore, that other valleys in the northern hills had been glaciated at low altitudes during the same period.

This was a new and important geological finding in Nepal.Much could be inferred from new findings of Quaternary deposits. In addition to a better understanding of glaciology itself, a better insight on the impact of low altitude glaciation on climatic changes during the Quaternary period can be attained. The presence of major glacial deposits within these populated northern areas has, however, other implications.

One critical issue is the extent to which undercutting of river banks and river beds takes place during high flow and flood periods in streams and rivers. Such processes resulted in landslides which filled in streams and riverbeds, perhaps damming them, with serious consequences such as floods and debris flows.This was a recurring process. Sediment characteristics were also favourable to the establishment of perched water tables which were also a triggering factor for landslides and mudslides.

While throwing light on the causes of recurring landslides and erosion processes experienced throughout the region,it also indicated that bridges constructed on the margins or within corridors influenced by these stream and river erosion processes were not safe; and the same was applicable to dams and reservoirs. In the reservoirs, slopes constituted of glacial deposits could be weakened by the buoyancy effect and could fail, causing the reservoir to silt up rapidly or, in the case of a major landslide, to be subjected to wave flooding.In the worst possible scenario, damage to or breaching of the dam would occur with the associated catastrophic consequences. The implications of glacial deposits at low altitudes meant that there should be a new approach to developing infrastructure as well as to watershed management in such areas.

Studies had been carried out in detail within an area of 70 sq.km. It was the first time in Nepal that such detailed work had been undertaken.

Discussion

The second half of Session One was taken up by further details of glacial analysis and discussion. During discussion, debate arose concerning the glaciation theory. Dr. D.R. Kansakar stated that he had found glacial deposits close to 1,000masl in the Hongu *Khola* Valley (Khumbu). However, another participant pointed out that there could be other explanations. A great deal of discussion ensued. Most of the participants were extremely interested in the findings and were enthusiastic to visit the field.

SESSION TWO

Instabilities and Hazard Mapping in Glacial Deposits

Mr. Alexis Wagner conducted this session.He informed the participants that three geophysical methods had been used by the project:namely; electrical sounding, seismic refraction, and seismic reflection.

The electrical sounding method involved identification of the glacial morphology and depositional features, as well as identification of layers prone to sliding and erosional processes according to resistivity.

The seismic refraction method helped to attain a more accurate picture of the shallow beds.It made possible the identification of layers that were prone to sliding processes according to velocity. A table of interpretation helped analyse the behaviour of the material.

Seismic reflection was useful for the detailed study of the valleys. It also helped to acquire morphological and lithological information of the overburden and bedrocks.

Mr. Wagner went on to discuss a model for hazard mapping and described the computer software SHIVA and its use.He described a hazard as *'a phenomenon of natural instability, active or latent, which included the potential of occurrence and extension,both occurrence and extension being inseparable'*.

Hazard map components were discussed. The main components were:

- nature/thickness of the material,
- material friction angle vs. slope angle,
- hydrodynamics of the streams vs slope,

- hydrogeology,
- till vs slope,
- landslide/gully erosion,
- land use,
- faults and thrust faults - reactivation, and
- reactivation of old slides.

Each component gives an indication of what type of failure is likely to occur, hence the components are rated accordingly. Mr. Wagner used transparencies to show the ratings for different components. This was followed by slides of hazard maps.

In discussing case studies and mitigation measures, it was stressed that farmers' participation and responses were extremely important in hazard mitigation. A number of landslides and gullies had been chosen for study. Landslides had been observed at Naguche, Hariyabesi, Kapre *Khola*, Bahrabise, Sano Palati, Sime, Dhuskung, and one gully at Dhuskung.The participants were shown slides of many of these places in addition to summary sheets of cost estimates for mitigation. A list of plant species that could be used to carry out bio-engineering methods of mitigation was shown and small-scale engineering methods of landslide control described.

Discussion

Some discussion took place. A question pertaining to the hydrological studies, particularly those pertaining to the capacity of the tributaries of the Khare *Khola*, Sani *Khola*,. Malati *Khola*, and Kagdhal *Khola* to dam the Bhote Koshi was asked. Dr. M.R. Dhital observed that there were four tributaries in the assessment. He noted that the bedrock could either collapse and form a rapid, or that sediments could form over a long time causing damming. The question was which could have occurred in this case. The answer was that it was believed that both processes could have occurred.

The speaker was alluding to the studies demonstrating that the four tributaries had capacity, under given conditions, that were likely to be met in the short-, medium-, or long-term, to dam the Bhote Koshi when significant peak rainfall occurs.This is due to the fact that, in given conditions, the Bhote Koshi does not have the immediate capacity, owing to its relatively low gradient, to move the debris inputs coming from its tributaries.

Another participant asked if it was a fact that geologists, according to a 1976 report, had believed the Arniko Highway to be well planned. There were supposed to be few landslides. In Langtang,

there were glacial deposits at 2,500m , in Khumbu at 4,000m, and in Ganesh Himal too the glacial deposits were at high altitude. But, at the last point under discussion, it had become very low.Why the sudden drop?The answer was that this was because of the younger glaciation.

Finally, some discussion centred once more around whether a single field investigation could prove conclusively that glaciation had taken place. Participants were invited to observe the points made during the field trip the following day. The third day of the Workshop would be reserved for group discussions, discussion in plenary, and conclusions and recommendations.

Part Two

THE FIELD TRIP

The field trip took place on the 9th of May 1996. The participants had an early start. Ten sites were scheduled for observation and discussion, although several stops that were not on the schedule were made. (As far as possible, we have recorded the observation areas according to schedule with brief observational notes.) The photographs in this section are all of the sites observed between Dolalghat and Kodari.

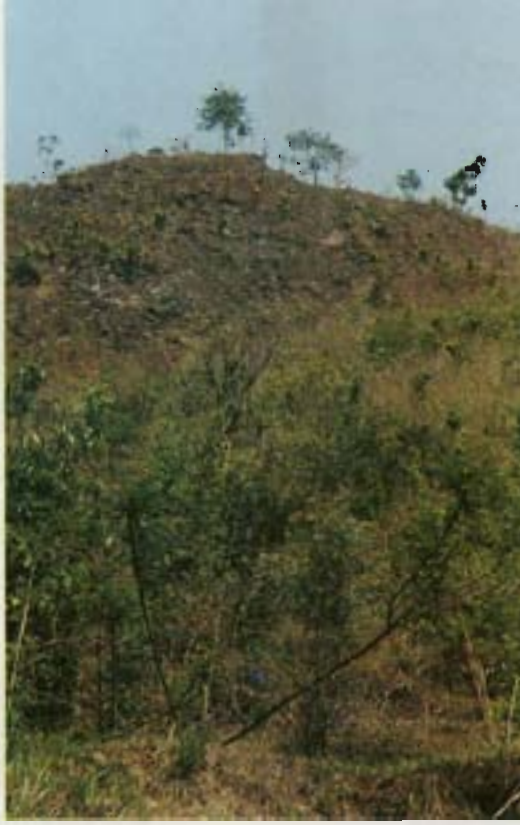


Plate 1

Observation of Glacial Deposits at Balephi

The first stop was at Kilometre 69. Dr. Pugin observed that this was the first sample of mixed glacial deposit soil in the valley.Horizontal drains had been built for stabilisation of the site. Dr. Pugin observed that along the river bank, the underlying deposits were probably of glacial origin (see plates 1 to 3).

Three stops were made around the Balephi area. The huge boulder before Balephi, which was referred to by the local people as the *Pancha Kanya* (five virgins) rock, was referred to by the project team as the Hanuman boulder (see plate 4). It was estimated to weigh from 60,000 to 70,000 tons. It lies close to the highway near Km 71 and is constituted of augen gneiss;this type of rock outcrops 40km upstream in Kodari and at shorter distances away (15-20km) in the tributaries of the Sunkoshi. The project hydrologists did not believe it possible that fluvial transportation had taken place over such distances; the river gradient was too low. This had led to the proposition that it could only have been transported by glacier. The geology differed from the surrounding rocks and from those at the roadside. At the stop made after Balephi, it was observed that, up to a depth of 80 metres, glacial materials had been found. Drastic changes in the profile of the bedrock had been observed between areas.

Plate 2

Plate 3

late 4

There was some discussion at this point. One of the observations was that the phenomenon observed could be due to the fact that the valley was sinking. The Main Central Thrust might be rising quite quickly in this area.It was then countermanded that, if this were indeed the case, why did the profile of the Bhote Koshi Valley tally with the one currently under observation? This introduced some lively discussions among the group. Reference was made to the profiles of the Lesser Himalayan and Midlands' residual soils.It was observed that colluvial soil can occur up to 10 or 20 metres, but certainly not up to 200 metres. In some areas in the research area, they had sounded up to a depth of 200 metres and bedrock was still not found.

It was concluded that the findings were unusual and warranted further investigation and confirmation by research in similar valleys.

Observation of Glacial Deposits at Lamosangu

The group stopped at Km79 to observe a site just before Lamosangu where electrical sounding had been carried out up to 55 metres. There was a sizeable flat area.The deposits were diamict overlaid by interstratified gravel. Pollen (grass) associated with a steppic cold climate had been found in a pond sediment horizon. Soils found were associated with a cold climate and, up to 40 metres down, the soil had low resistivity. The total depth of deposits was not known but bedrock had not been detected up to 500 metres (see plate 5).

Plate 5

Observation of Landslides and Glacial Deposits at Kilometre 83 - Sunkoshi Confluence

This was a probable kame terrace (viz., sub-aquatic sediments deposited on the lateral margins of glaciers). The seismic profile along the river was conducted over a trough typical of glaciers. Electrical sounding had been carried out up to 15 metres without reaching the bedrock. On the opposite side of the river from the road, the morphology was typically glacial.The water table was below the river. It was observed that seasonal crops had been planted and were growing robustly despite the fact that there had been no rain and the land was not irrigated. Project team members recalled that the area was swampy when they first investigated it. This was because of the high water table and clay close to the ground surface.There was a great deal of toe erosion. It was observed that bioengineering techniques could improve this site, but it would revert to the present conditions after one or two years. Following this site, mudslide and fluvio-glacial deposits were also observed.

Observation of Kame Terrace and Glacio-Lacustrine Deposits at Kilometre 92 and Malati *Khola*

In the Malati area, a number of stops took place. Loess deposits were observed and,in the Malati catchment area, the frontal moraine of a cirque glacier.The moraine was observed to consist of carbonic rock clasts. It formed a pyramid visible from the road.The large rock outcrops had features typical of glacial erosion. In addition, the group observed glacial till material below a large boulder on the left bank of the river.The material had characteristics of shear action of the cirque glacier. The outcrops were broken and fissured as a result of the pressure caused by the cirque glacier. Landslides and glacial deposits between Kilometres 96 to 98 were also observed.

Observation of Till at Kilometre 102

This spot was close to the road bridge at Kilometre 102 on the right bank of the Chaku *Khola* (a left bank tributary of the Bhote Koshi). The morphology of most of this outcrop was median moraine. It is situated at the junction of two old glaciers, i.e., the Chaku and Bhote Koshi glaciers. Material samples had been collected and morphometrical and grain size distribution investigations corroborated that the material was till.

Observation of Lodgement Till at Kilometre 104

This area was on the right bank of the Lang *Khola*. The material here was very thick (60m) and, the landslide itself about a kilometre

long. Material typical of glaciation indicated that the thickness of the material probably resulted from a progressing glacier.

Kodari

The material observed above Km 112 in Kodari was hard-clast supported diamicton.The high compaction was taken as an indication of glacial origin and morphometrical studies were undertaken to determine that the material was glacial till.

The Return Journey

On reaching Kodari, it was decided that two or three sites would be visited on the return journey. The project team members also suggested that the participants might like to look at a possible landslide hazard mitigation site that they proposed to work on if the project went into a second phase. The group agreed to this idea. The group was also able to view an engineering team drilling on a dam site near Kilometre 109.

The engineers discussed the difficulties they were having with members of the group. There was a certain amount of scepticism concerning whether this was a good place for a dam or whether it might be destroyed in the same way as the Friendship Bridge in 1987.

One of the most interesting stops on the return journey was the observation of the landslide below the village of Naguche. It was hoped that a second phase of the project would be sanctioned and that measures to mitigate this landslide hazard would be undertaken. Mr. Wagner explained that this village had a mixture of ethnic groups (*Tamang, Kshetri, and Newar*), but the people had been cooperative and unanimous about their desire to control the slide. It was easy to see why. The slide began below some terraced fields endangering the village school. Exacerbation of the slide could possibly result in the village school falling into the river.

Naguche was the final stop on the field trip. It had been a long day and an extremely interesting one.

Part Three

SESSION THREE

The participants met briefly in a plenary session prior to dividing into discussion groups. **Professor Suresh Raj Chalise** chaired this brief session. He explained that, although originally it had been planned to divide the forum into three groups, after some consideration it had been decided that the subjects of `Hazard Mapping' and `Application of Community Oriented Erosion Techniques for Landslide and Gully Erosion Control' were interrelated and that, therefore, these subjects would be discussed by one group, i.e., Group Two:`Hazard Mapping and Soft Engineering'. Group One would discuss 'Understanding, Identification and Practical Implications of Glacial Quaternary Deposits in Nepal and the Hindu Kush-Himalayan Region'. Participants were allotted their groups and technical and language rapporteurs assigned. The members of each group are given in Annex Three.The group discussions have been recorded in order to clarify how recommendations came about. As far as possible, speakers are identified.

In considering the group discussions and recommendations to be made, Professor Chalise asked the groups to follow a certain formula.

Based on the report,the presentations, the discussions, and the field visit, what is the opinion of the group regarding

a) the main achievements (conceptually and practically) of the work so far; who is likely to benefit most from this work and how ?

b) the major limitations of the work and, more specifically, in which areas?

c) what should be done next, which aspects (subject areas, issues,etc) need greater emphasis and are there components that should be reduced in emphasis? and

d) ICIMOD has a regional mandate; what are the main regional implications of this present work? What should be the next step for a regional programme (regional meeting, invitation to concerned agencies in the region for discussion,etc)?

The groups were to conduct their discussions according to these points, formulate their recommendations, and present them at the final, plenary session.

SESSION FOUR

Group One - Understanding, Identification, and Practical Implications of Quaternary Deposits in Nepal and the Hindu Kush-Himalayan Region

Dr. Pugin was the Chairman for Group One and opened the discussions by stating that the problem should be solved by considering all the facts and fitting them into one of two models,i.e., a glacial model or a debris flow model.He added that the phenomenon they had been observing was not new, it had been found before. It should now be discussed.He opened discussion by suggesting that the group deal with the points in the guidelines for group discussion given by the Chair.

Discussions

Dr. M.R. Dhital pointed out that there was now a lot of information on Quaternary deposits between Balephi and the Friendship Bridge. This information was quite detailed, giving new inputs for new methods of enquiry and new applications in geophysics. In fact, seismic reflection was quite new in the context of Nepal since resistivity was the method that had been used in the past.

Some exchange took place among group members concerning the merits of old and new methods of analysis.

Dr. Dibya R. Kansakar stated that one of the main achievements had been that a new issue for further scientific research had been raised, because it was now essential that the possibility of glacial deposits at lower levels be examined.This would have a great impact not only on applications but also on science itself.

In Nepal, such phenomena have occurred up to 2,400metres. The latitudinal effect is also there. Notwithstanding, this finding is a first for this part of the Himalayas. It is a big issue and needs to be studied further.There are doubts because glacially good landforms are not preserved, yet the deposits are there indicating past glacial activity.

Dr. M. R. Dhital rejoindered that the findings had direct implications on infrastructural development. The scientific content of the report was good, grain size analysis and geophysical interpretations had provided good data. One model had been proposed and the team had good evidence to support it.

Dr. C.K. Sharma stated that the research had opened up a new idea; the idea of looking at glacial deposits, particularly in valleys.

Until now, Quaternary deposits from GLOFS only had been studied.This work suggested that they should be looking at older glaciation. If one were to ask what the benefits would be, the answer would be that the country will benefit. Road and hydropower departments in particular should look into these deposits. Hydropower sites would have to be more carefully selected.

Dr. B. P. Upadhya stated that the conceptualisation in the past had been that there were glacial deposits at depth in the lower regions. Is this concept still valid? Was the material glacial or fluvial?The conceptualisation needed verification. We had to be very clear. Was this a concept or was it merely anticipation? He suggested that more study would be necessary to clarify these points for the sake of validifying the concept and giving more rationale to its validity.

Mr. Narendra Khanal stated that the work had succeeded in identifying channels,or implications of geohydrological channels.The impacts and the benefits of this would mainly apply to the Department of Roads and the Department of Hydrology, no matter whether the deposits found were due to glaciers or rivers.

Dr. Andre Pugin, at this point, summarised the points that the group should be looking at. He stated that the project had used new methods or improvements of old methods in the first phase and had, hence, found new facts in Northern Nepal. Consequently, the discussion was concerned with whether the new model was glacial or fluvial and what would be the implications in practice.

Dr. B.N. Upreti stated that, further north, the material differed from that in the south. The material was very thick and fragile north of Balephi, and this would be a problem for road alignment. Methods of hazard mapping were very important. When the Lamosangu-Jiri road was built, it was the first time that mountain risk engineering methods had been used, now hazard mapping of a larger area had been done and the methodology improved. This should now be applied to other areas. He suggested that the work had led to improvements in hazard mapping and that new parameters had been established in geophysics and geology in the area. He appreciated the relationships formed and the sharing of knowledge between Swiss and Nepalese scientists. Dr. Upreti said he looked forward to further participation.

Mr S.R. Pant added that there had been improvements in geophysical methods and that it was the first time the seismic reflection method had been used in Nepal on Quaternary deposits.

Dr. C.K. Sharma noted that, since the work had only been carried out in the Bhote Koshi and Sunkoshi area, it should be carried out in other areas also, probably in East Nepal. Findings there would substantiate the work already carried out. This work should be carried out over a limited period of time and systematic glacial mapping should be carried out.

There was an ensuing discussion about the difficulties involved in glacial mapping, although the moderator noted that geological maps were available and these could provide a start. The group consensus was that glacial and morphological maps were a must and that the maps should be updated. Geophysical data needed confirming and every effort should be made to do so.

Dr. B.P. Upadhaya mentioned what he considered essential in terms of further work. He said that ages of the rocks were not known and climatic and drainage data had not been confirmed. He saw work to fill these gaps as essential in any future project phase.

Dr. S.K. Manandhar mentioned that the graphical respresentations needed redrawing. Dr. Pugin agreed. Mr. Manandhar asked if Dr. Pugin believed that the deposits of the huge boulders from Jurikhet *Khola* to Bhainse had been by debris flow. Dr. Pugin replied that this had to be seen within context and that he believed they had been.

Dr. M.R. Dhital said he felt that the project should have taken the work of others into consideration. For example, he quoted Sue Downing's work on Glacial Lake Outburst Floods in 1982. Dr. Dhital read an excerpt from Ms. Downing's work. He added that two of the figures in the report appeared to be from this publication but he was unsure of the referential background. He went on to note that since most of the channels were v-shaped, this would surely denote fluvial not glacial origins of the channels. He believed that further study was needed in order to confirm the findings and that, in doing so, previous studies should be taken into full consideration. All deposits from Dolalghat to the Friendship Bridge should be mapped and confirmatory drilling should be carried out in one place at least to confirm the nature of the buried material. Dr. Dhital suggested that a comparative study should be carried out in the *Terai* where similar deposits (which are not glacial, however) can be found. He thought that confirmation of the clast was essential. Also essential was that prominent glaciologists should be brought in and their opinions sought.

Dr. D.R. Kansakar said that the new model had not been compared with the existing model (fluvial cf. glacial), samples from

neighbouring areas had not been examined, and that samples were mainly from the Bhote Koshi Valley. Features from side tributaries should be examined and deposition on all sides of the valley should be compared. Why had the gneissic boulders on the side walls not been given as examples? There had also been no inference concerning identification of different glacial periods. This would have been helpful. Detailed sedimentological studies of different stages of glaciation were not given.

Taking all this into consideration, he said that the study area in Nepal should be extended. It should then be extended to the Hindu Kush-Himalayan region and extensive expert discussions held. He asked if this new concept could be proved. He stated that to do so would necessitate the use of new techniques and new methods.

Dr. Pugin apologised to the group because it had not been possible to make the full report available before the workshop. He believed that some of their misgivings would be answered when they read the full report.

Discussions under point `d' were concerned with recommendations. These were to go to the final plenary session for consideration by both groups and finalised at that point. With this in mind, the recommendations of Group One have not been given here. It was, however, unanimous among the group members that further work in this area was essential. Dr. C.K. Sharma was keen on the idea of ICIMOD calling together a multidisciplinary conference to discuss the findings. He also felt that, since ICIMOD was already involved in this work, perhaps it could constitute a multidisciplinary committee from Nepal ; a core group that should always be kept informed on the progress of the work. The applied side of the science should always be closely allied with ICIMOD.

Professor S.R. Chalise pointed out that, although he agreed that a leading organisation should house the core group, it should not be ICIMOD. ICIMOD could facilitate and support the core group, but it was not in a position to house it.

This led to quite a lot of discussion about who should house the core group; Tribhuvan University, the Water and Energy Commission Secretariat (WECS), the Disaster Prevention Technical Centre (DPTC), or the Mountain Risk Engineering (MRE) unit at Tribhuvan University. Dr. M.R. Dhital pointed out that the MRE unit of the Department of Geology had proved its worth. It had many prominent scientists and government representatives on its board and was quite capable of housing such a core group.

Group members were unanimous about the core group and discussion ensued about where the funding could come from. There were various suggestions;Global Environmental Facility (GEF), Economic Commission for Asia and the Pacific (ESCAP), Swiss Development Cooperation (SDC), European Economic Community (EEC), International Commission on Erosion and Sedimentation (ICES), and so on. The Swiss Development Cooperation was the organisation that everyone agreed on. It was a question of whether SDC was in a position to help.

Recommendations from this group were unanimous, and the group disbanded to attend the final session of the workshop.

Group Two:Hazard Mapping and Soft Engineering

Mr. Alexis Wagner chaired the group discussions which opened with the following points. In Nepal, major efforts had to be made to carry out more work on Quarternary deposits because most landslides occurred on Quarternary deposits. There was a need to

- identify how to introduce the study of Quarternary geology;
- discuss the implications when infrastructure is built in Nepal;
- receive some input from the Department of Roads' (DOR) on-going extension programme for landslide stabilisation; and
- suggest alternative use of land that has been stabilised – agri-culture, horticulture, or a more whole and integrated forestry -- also put a group of local people in charge of the project.

The main objective was stabilisation and identification of an instrument to cope with landslides in the future. There was a consensus that hazard maps were essential to achieve this and that they were not the same as geotechnical maps. Any road construction undertaken without hazard mapping would be prone to landslides. Most roads/highways, even Arniko Highway, had been constructed without studies, except in the case of the Gaighat-Okhaldhunga road for which hazard maps were prepared.

Mr. P. Rohner added that hazard maps would be a part of the study and that it would also include geomorphological and aerial studies which would be conducted before any infrastructural development took place. Mr. Khanal suggested that, since most slides are induced by rains, hydrometereological studies should be undertaken at higher altitudes.

Mr. Wagner said that, granted that the hydrological study was essential, they had no existing data. In the project, they had taken the river flow into account – the hydrological approach. Therefore, he recommended that, while the need for hazard maps was stressed,

they also needed to take hydrological data into account, and this applied to all watershed areas. For hazard mapping, the catchment area had to be defined.

- The scale of the aerial photo maps should be 1:25,000.
- The hydrometereology of the catchment needs to be defined and for this hydrology and geology have to be assessed, therefore, geophysics is important and geophysical instruments should be used.
- Land-use maps are also needed.
- Cadastral maps are needed but are difficult to find.
- Previous reports, i.e., documentation, need to be consulted.

Mr. Wagner added that, during preparation of hazard maps, a scale of 25,000-50,000 should be used to be consistent with regional mapping.

Mr. Pradeep Mool said that all the maps of Nepal were being digitised by ICIMOD.

Mr. Wagner explained how the designs for stabilisation structures would be established. Hazard maps were useless for prefeasibility, so at this point topographical maps would be used. Following this, hazard mapping would be carried out and a detailed study done. A design would be decided upon as a consequence. Mountain Risk Engineering (MRE) prefeasibility was a part of this procedure.

It was asked whether any drilling and draining would be required during the preparation of hazard maps. Mr Wagner explained that these would be required in catchment areas and roads sometimes, but, by and large, they would use geophysics which gave them some information on the content and formations under ground. He added that geophysical investigation was new in Nepal.

There was a general consensus that people's participation should be maintained. They should know what the project was doing, in fact, they should be motivated to maintain the watershed.

Mr. P. Rohner raised some pointed questions that needed to be addressed. *"Whenever we reach a catchment area site for a hydroelectric scheme,* he said, *there are never any hazard maps, if any they are on different scales. Also, we need to sort out who keeps the maps and who are the users."*

Mr. Wagner said that the hazard maps should be shared by all, from the forester to the engineer, and they should be comprehensible and not too technical.

A question was raised about the data on demographic distribution. Mr. Wagner said that, in an area under demographic pressure, these were essential. He referred to the work carried out with the Hindi village demographic data. He added that the details of the hazard maps changed with the requirements depending on whether they were to be used for a road or a dam. The main aspects of the study were geology, hydrology, forestry, and land use. Land use was assessed for hazard mapping and not from the income/output perspective of crops or anything else.

It was agreed that, in the initial stages, an economist/sociologist should be involved and that the following would be required.

- Topographical map
- Aerial photos
- Geological maps
- Land-use maps
- Hydrometeorological data
- Geophysical survey

It was recommended that line agencies should maintain documents. It should also be made clear which agencies were involved and in what way.

It was recommended that Quarternary studies and hazard mapping should be introduced into the curriculum at the Department of Geology of Tribhuvan University. Most of the training material was already available. Mr. Wagner said they should start with the topographical map and come out with their own hazard maps. Prior to this, a month-long training course for trainers could be organised. This would make hazard mapping an ongoing technique.

For Soft Engineering Techniques, Biotechnical Engineering, and Drainage, Mr. **Rohner** gave the example of Bhutan's on-the-job training of labourers as very fruitful. It was stated that the farmers needed to be motivated to participate.

Mr. Wagner said that for community-oriented soft engineering techniques five slides for direct penetration had been selected, and farmers could be trained near the road corridors.

One participant suggested that DOR engineers could train farmers in the Bhote Koshi catchment area. It was also suggested that the DOR work be linked with the Swiss Development Cooperation's (SDC) work.

It was added that since the DOR could not go beyond the road corridor, it would be advisable to involve the District Development Committee (DDC) and the Village Development Committees (VDCs) where most of the irrigation and infrastructural construction took place without hazard mitigation considerations.

Mr. M. Upadhya of the Bagmati Watershed Project brought out some pitfalls. In one instance, a landslide area they were working on was very small and, to stabilise the landslide, the adjoining land had to be acquired at a high rate. This would sometimes tempt the farmers to induce a landslide for the sake of the money.

It was also recommended that there should be coordination between the Department of Roads, Department of Mines and Geology, and the Department of Soil Conservation. It would be advisable to form a Steering Committee and connect the project to an agency, so that it could be replicated and propagated on a long-term basis.

The general recommendations were finally agreed upon for presentation at the final session.

SESSION FIVE: PLENARY DISCUSSIONS, CONCLUSIONS, AND CLOSURE

The organisation of this Session was fluid in the sense that the closure followed on directly from the plenary discussions without a break. Since recommendations were not altered, but rather reinforced, during the plenary discussions, comments by the plenary session were preceded by the group recommendations as **finalised** and **accepted** by the plenary.

Professor S.R. Chalise chaired the plenary discussions and the concluding session. He opened the session by explaining that the recommendations from each group would be put to the plenary session for discussion and finalised. He requested **Dr. Pugin** to present the report and recommendations from Group One.

Dr. Pugin explained that Group One had been very well organised and had kept to the schedule of the four points suggested by the Chair. The recommendations from Group One were put to the plenary.

Group One Recommendations

- Further morphological mapping should be carried out.
- Outcrop sedimentological analyses should be undertaken.

- Dating should be carried out.
- All references should be drawn together and comparative glacial and fluvial theories should be discussed more extensively in the presentation.
- Further geophysical investigations should be undertaken.
- More geophysical investigations should be made downstream and the extent of the channels examined (perhaps also cf should be made with areas in the south,e.g., Narayanghat)
- Other valleys should be investigated
- Climatic analyses should be carried out.
- Further work should involve both Nepalese scientists and other earth scientists from the region and then from the rest of the world; following this a conference should be held.
- Tribhuvan University should have a Quarternary geology curriculum.
- In relation to point nine, if these findings have lateral extensions, ICIMOD should invite multidisciplinary experts from the region to a workshop.
- A core multidisciplinary group from Nepal (including different users) should be constituted.This group should be kept informed of progress. ICIMOD could facilitate this.
- ICIMOD should be closely involved in the applied side of these research findings.
- Suggestions for organisations to house a core group include the MRE unit of Tribhuvan University, Department of Geology, WECS, and DPTC.
- Suggestions concerning donors that could be approached: SDC, ESCAP, ICES, and EEC if linked to MRE.

Discussions on the recommendations were helpful. **Dr. Pant** from Group One added that Paleo-valleys should be explored also from downstream of the Sunkoshi and Balephi confluence.

Mr. Alexis Wagner, who had been the coordinator for Group Two, said that he felt drilling was beyond the financial means available. It had been tried along the Arniko Highway. Dr. Pugin commented that if an organisation working in applications had the necessary equipment then the university could use it. There should be better coordination between research and application.

Dr. B.N. Upreti drew everyone's attention to the importance of maps. He mentioned that two new hydro projects were in the offing and that,in that context, the maps produced by the project were important. He also stated that the question of glacial or non-glacial deposits was still going on. If one went tens of kilometres further up and if one could explore further upstream, across the border for example, then perhaps the findings could be confirmed.

Professor Li Tianchi thought that it was a good idea to carry out research 30 to 50km across the border.

Mr. Wagner said that this would mean that they would need visas and a letter from the Chinese Academy of Science. Professor Li did not think this would be a problem, and Professor Chalise remarked that this was an area in which ICIMOD could facilitate.

Mr. Patrick Kilchenmann asked if anyone had estimated how much time would be needed? Dr. Pugin replied that, presuming the money could be found, they could extrapolate from the Kodari Valley. They could also be selective according to the finances available. Mr. Wagner felt that the current study was a pilot study and wondered how feasible it was to go beyond the catchment. Dr. Pugin emphasised that study of one or two other valleys was important for research. Professor Li added that it would be good if money were to be made available for two or three other valleys. It might be too early to start at this juncture, but if results were taken from the one catchment area it would provide them with a model and standards for the other valleys. Dr. Upreti reminded them that the idea to extend had arisen from the initial controversy over the Quaternary deposits. It wasn't that every valley needed to be studied, just one or two and comparison of sediments. Dr. Kansakar added that, perhaps, they would be very lucky if they could find definite confirmation of the findings. Perhaps it was important to establish the findings.

Continuing on the point of future studies, **Mr. P. Rohner** stated that, at present, only a small area was mapped. They had to look further up. It would be greatly appreciated if those who were going to do the study had the opportunity to see parts of the area further upstream. He wondered if it would be possible, since ICIMOD did not stop at the border, for ICIMOD to facilitate this? Mr. Wagner said he was in full agreement with this point of view. Professor Chalise stated that it should be possible and Professor Li concurred. Mr. Rohner noted that Switzerland and China had always maintained very good relations.

Dr. Upreti said that they should begin to discuss the next phase and the scale of work as soon as possible. This should be planned out

on as fine a scale as possible. Even if there was no evidence of glaciers along the valley, as one goes further north one sees the same disasters and hazards as those caused by glaciers in many places. If this work could be concretely based in China also, it would only take a few weeks to relate upstream to downstream glacial deposits.

Dr. Pugin said that the upper catchment had already been studied by Chinese scientists. First they should meet with them. The Chinese had good publications on Quaternary deposits

Discussions on the recommendations of Group One concluded and consensus was reached. The Chair then invited Mr. Alexis Wagner to report on the work of Group Two.

Mr. Wagner commenced his report by reading out the recommendations from Group Two.The recommendations were in two parts: `Hazard Mapping' and `Application of Community Oriented Soft Engineering Techniques for Landslide and Gully Erosion Control'.

Group Two Recommendations

Hazard Mapping

- Hazard maps are needed for water catchment management and infrastructural projects (canals, roads, dams). Hazard maps permit the identification of hazard zones which have to be assessed in detail with geotechnical investigation.
- Design of infrastructure and water catchment management should be carried out on the basis of /after consultation of the above-mentioned maps.
- Training in hazard mapping would be the responsibility of teachers-trainers in the context of future use.For implementation, it is recommended that the Department of Geology of Tribhuvan University become the responsible body.
- It is recommended that a group of geologists, engineers, foresters, hydrologists, agriculturalists, and geophysicists, as resource persons, link up with other specialists, e.g., socioeconomists and environmentalists.

Application of Community-Oriented Soft Engineering Techniques for Landslide and Gully Erosion Control

- It is recommended that stabilisation of landslides and gullies damaging the farm land and threatening the roads be carried

out as on-the-job training for farmers, civil engineers, foresters, geologists, hydrologists, agriculturalists, and geophysicists.

- It is recommended that responsibility lie with the Department of Roads and the Ministry of Local Development to work in collaboration with each other in this field.

A lot of discussion ensued. There were many opinions and suggestions. Certain participants thought that HMG/Nepal certainly did not have sufficient gauges. Others believed that topographical maps posed a problem ; they were usually on a scale of 1:50,000 whereas 1:10,000 to 1:25,000 was usually the more reliable range for hazard work. Aerial photos also should be 1:25,000.

There was some discussion about the definition of a corridor, was it one or two kilometres? Some participants thought it should be two kilometres on each side of the road.

It was stated that Quaternary deposits should be mapped, but participants pointed out that this had been covered in the recommendations of Group One. Hydrometeorology should also be taken into account for hazard mapping and use should be made of land-use maps and cadastral survey maps. Regarding the hazard mapping, it was agreed that, in this context, it was up to geophysicists to define the parameters.

In general, it was agreed that all points raised were comprehended within the recommendations given. However, there was some discussion about identifying an organisation for the core group recommended. Many participants thought it should be housed at the Department of Geology, Tribhuvan University. In any case, it was decided that the discussion could not be concluded at that time, and that the onus could perhaps lie with ICIMOD to convince or identify a likely organisation.

Dr. C.K. Sharma stated that, unless the government was involved, nothing would get done. He wondered if the Department of Mines and Geology could do the geological mapping since they had money and manpower. He also felt that the responsibility of building more hydrological stations should be with the Department of Hydrology and Meteorology. How could the SHIVA dambreak model be transferred to them, for instance? Dr. Sharma was also dubious about the capabilities locally for using the 500,000 rupees per annum allotted by the Local Development Department to Village Development Committees. He observed that, unless they had technical manpower, they would not be able to use this money appropriately.

Mr. Wagner stated that the Department of Geology of Tribhuvan University would be trained in SHIVA methods. It was quite acceptable that the Department of Mines and Geology should be involved, but a teaching core was essential in the first instance. When the teachers at Tribhuvan University had been trained, they could then train people from the Department of Mines and Geology. Training teachers was of primary importance. The course should become a curriculum item.

Some discussion ensued about the maps themselves. **Mr. Narendra Khanal** said he thought that high precipitation zones should be marked and included in hazard maps. Mr. Wagner agreed but said that it should be integrated, and this was the reason why a multidisciplinary core group was essential; a hazard map could be improved at any time.

Dr. M.R. Dhital said he wished to express his appreciation of ICIMOD for the interaction they had been facilitating over an appreciable period of time. He mentioned ICIMOD's work on mountain risk engineering and in training in GIS. He also wished to draw people's attention to the fact that, although many were sceptical about the relationship between Tribhuvan University and the government, there was no need to be. Currently, the Mountain Risk Engineering unit was training six engineers from the Department of Roads in bio-engineering. They had a pool of trainers and were willing to impart training wherever needed. The MRE Unit had a good reputation and had always received excellent cooperation from the government, government officials sat on its Committee. Anyone from Tribhuvan University could be called into the MRE Unit. Dr. Dhital stated that the EEC was very interested in this Unit as well as the ODA. It had got off to a good start and thanks were due to ICIMOD for this. People were sceptical in the beginning, but now it was doing well.

Professor Chalise brought the discussions to a close by stating that the point concerning whether Tribhuvan University should be entrusted in Phase Two of the project, if there was to be one, had been well answered. Since there was no further discussion on any of the points, he suggested that the workshop conclude. He, therefore, handed over the chair to **Mr. Egbert Pelinck**, Director General of ICIMOD.

Mr. Pelinck opened the discussion once more for final conclusions and recommendations. Dr. Pugin and Mr. Wagner rebriefed the plenary on the recommendations made by the two groups.

Mr. Pelinck then addressed the plenary. He remarked that he wished to thank them all. The workshop had been interesting, at times

controversial, which made it more interesting. He thanked, in particular, Mr. Pius Rohner of SDC for spending so much of his valuable time attending the workshop. "*Hopefully,*" Mr. Pelinck said "*this is an indication of his interest in the second phase.*"

Mr. Pelinck thanked Professor Chalise for his constant attention to the organisation of the workhop. He said that he, personally, had been grateful for the opportunity to share in the discussions. He regretted not being there a 100 per cent of the time and that he could not participate wholly intellectually in all subject areas, but he had learned quite a bit about geology and a lot about the commitment of the participants present. He believed the interest of all had been captured by the amount of information they had all received on the first day. He was very grateful to the team of consultants for all the work they had undertaken in both gathering and analysing data. Over the period, a lot of information had been gathered on Quaternary geology. He assured the participants that ICIMOD was always interested when something in Nepal is of interest to other countries in the region.

He understood the need for follow-up and the need for the involvement of a number of parties. ICIMOD should also play a role. It became even more interesting when things in a document were translated into action. ICIMOD could not compete with big donors, but, if needed, it was interested in other organisations and national institutions; in strengthening national capacities in the Hindu Kush-Himalayas.

Mr. Pelinck said he was pleased to hear that Tribhuvan University and other line agencies were interested in further involvement. National Training needs should be looked at. This, of course, needed money, but money could be found if one had a good programme. ICIMOD could be a facilitator in getting the needs across to potential donors and would make every effort to identify donors.

Mr. Pelinck was highly appreciative of the role of SDC. He said that the SDC had given ICIMOD a small grant on the occasion of the U.N.'s International Decade for Natural Disaster Reduction (IDNDR) and this had enabled them to begin to make inroads. He thanked Mr. Wagner and Dr. Pugin also. He stated that it was obvious that they had put in a lot of overtime that was actually free time. A lot of dedication had gone into this work and it showed in the excellent results.

Mr. Pius Rohner of SDC thanked Mr. Pelinck and Professor Chalise for the work carried out by them in coordinating the workshop. He thanked Mr. Wagner for his spirit and push and Dr. Pugin for coming from his work at the University of Geneva to take part in the research.

He thanked all the participants for their enthusiasm and, in particular, all those who had worked in the field.

It had been an interesting time and an interesting pathway had been opened up. There were a few little stones in the path, because he could not at that moment commit anything. The decision would have to be made by SDC. He assured everyone of his commitment. Mr. Rohner stated that there was a great deal of interest in the Arniko Highway which lay almost entirely in the project area. He reminded everyone that, in future, district roads would be built, and these would also need geologists not only engineers.

Mr. Rohner's final point was pertaining to disaster relief. He assured them that the Swiss relief mechanisms would be ready to help Nepal in any way possible in the event of a disaster. They were fully aware, in this respect, that disaster not only needed help and relief mechanisms but also prevention mechanisms. Small disasters had probably more human-related implications than big ones."*As for the future,*" he said, "*I am optimistic.*"

Mr. Pelinck closed the workshop with the following statement.

"*That remark brings us to the end of the workshop.Ending on a positive note is the best way to end. Thankyou all for taking part. We will write a report and keep you informed.Thankyou.*"

Annex 1
Programme

Day 1:
May 8, 1996

8:30 - 9:00	Registration
9:00 - 9:15	Welcome Address, *Mr. Egbert Pelinck, Director General, ICIMOD*
9:15 - 10:00	Background of the Workshop, *Mr. Alexis Wagner*
	Sesssion One
10:00 - 11:00	Glacial Basin Analysis of the Northern Sunkoshi and Bhote Koshi Water Catchment Areas, *Mr. Andre Pugin*
11:00 - 11:15	Teabreak
11:15 - 13:00	Glacial Basin Analysis (Continued) and Discussions, *Mr. Andre Pugin*
13:00 - 14:00	Lunch Break
	Session Two
14:00 - 15:30	Instabilities and Hazard Mapping in Glacial Deposits *Mr. Alexis Wagner*
15:30 - 16:00	Teabreak
16:00 - 17:00	Instabilities and Hazard Mapping (Continued) and Discussions, *Mr. Alexis Wagner*
19:00	Dinner Hosted by Mr. Egbert Pelinck, Director General of ICIMOD at HOTEL SUMMIT

Day 2: Field Trip Programme
May 9, 1996

7:30	Start from ICIMOD.
9:00- 9:20	Tea at Dolalaghat (20min), *Stop 1*

10:15 - 10:45 Observation of Glacial Deposits at Balephi (30min), *Stop 2*

11:00 - 11:30 Observation of Glacial Deposits and Discussions on Paleoclimatic conditions at Lamosangu (30min), *Stop 3*

11:45 - 12:05 Observation of Landslides and Glacial Deposits at Km 83, Sunkoshi confluence (20min), *Stop 4*

12:15 - 13:15 Observation of Mudslide and Fluvio-Glacial Deposits (30min), *Stop 5*

12:45 - 13:15 Lunch Break

13:15 - 14:00 Observation of Kame Terrace and Glacio-Lacustrine Deposits at Km 92, and Malati *Khola* (30min), *Stop 6*

14:00 - 14:30 Observation of Landslides and Glacial Deposits at Km 96-98 (30min), *Stop 7*

14:40 - 15:00 Observation of Lateral Fill at Km 102, Chaku (15min), *Stop 8*

15:05 - 15:35 Observation of Major Landslides and Glacial Deposits at Km 104, Hindi (30min), *Stop 9*

15:50 - 16:05 Observation of Paleo Glacial Valley at Km 112, Kodari (15min), *Stop 10*

16:10 - 16:25 Observation of Paleo-soil and sequence of Fluvial and Glacial Deposits at Liping/Tatopani (15min), *Stop 11*

17:00 - 20:00 Return Journey to Kathmandu

Note:

The vehicle will leave ICIMOD at 7:30am sharp.

A Lunch Packet will be provided.

Please bring an umbrella or a raincoat and necessary field gear. It is suggested that you bring a pair of binoculars, if you have them.

Day 3
May 10, 1996

Session Three

9:30 - 10:30 General Discussion on Observations in the Field: Glacial Deposits and Practical Implications for Infrastructural Development and Watershed Management

10:30 - 11:00 Tea Break and Group Formation

Session Four

11:00 - 12:30 Group Discussions (Group I, Group II, and Group III)

Group I: Understanding, Identification, and Practical Implications of Glacial Quaternary Deposits in Nepal and the HKH Region

Group II: Hazard Mapping

Group III: Application of Community-oriented Soft Engineering Techniques for Landslide and Gully Erosion Control

Note: Subsequently Group II and III became Group II - refer text

12:30 - 13:00 Presentations by the Groups (10 mins each)

13:00 - 14:00 Lunch Break

Session Five

14:00 - 16:30 Discussion and Presentation of Group Recommendations and Final Conclusions

16:30 - 17:00 Tea/Coffee

Annex 2
List of Participants

1. Dr. Bishal Nath Upreti
   Head, Department of Geology
   Tribhuvan University
   Trichandra Campus, Kathmandu
   Tel: 416386

2. Dr. Megh Raj Dhital
   Lect., Central Depart. of Geology
   Tribhuvan University
   Kirtipur, Kathmandu
   Tel: 529383

3. Dr. Vishnu Dangol
   Lect., Department of Geology,
   Trichandra Campus
   Kathmandu
   Fax: 473563

4. Mr. Surendra Raj Pant
   Lecturer
   Central Depart. of Geology,
   Tribhuvan University
   Kirtipur, Kathmandu

5. Mr. Danda Pani Adhikari
   Asst. Lecturer
   Department of Geology
   Tribhuvan University
   Kirtipur, Kathmandu
   Tel: 221523

6. Dr. Bidur Prasad Upadhyay
   Head
   Central Depart. of Meteorology
   Tribhuvan University
   Kirtipur, Kathmandu
   Tel: 221253
   Fax: 226694

7. Mr. Khadga B. Thapa
   Associate Professor
   Central Depart of Meteorology
   Tribhuvan University
   Kirtipur, Kathmandu
   Fax: 229231

8. Mr. Hari Krishna Saiju
   Scientific Officer
   Royal Botanical Garden
   Godavari, Lalitpur
   Tel: 290547
   Fax: 290549

9. Mr. Narendra Raj Khanal
   Lecturer
   Central Depart. of Geography
   Tribhuvan University
   Kirtipur, Kathmandu
   Tel: 222129

10. Dr. Madan Lal Shrestha
    Deputy Director General
    Depart. of Hydro. & Meteo.
    P.O. Box 406,
    Babar Mahal, Kathmandu
    Nepal
    Tel: 215979
    Fax: 224646

11. Dr. Sharad Prasad Adhikary
    Executive Director
    Water and Energy Commission
    Singha Durbar, Kathmandu
    Nepal
    Tel: 228969
    Fax: 227185

12. Mr. Shyam K. Manandhar
    Hydro./Hydraulic Engineer
    Soil Test Pvt. Ltd.
    PO Box 2967, Baneshwor,
    Kathmandu
    Tel: 475946
    Fax: 470551

13. Mr. Pius Rohner
    Asst. Coordinator,
    SDC, Ekanta Kuna,
    Jawalakhel
    Tel: 524927-30

14. Dr. Tomomi Yamada
JICA Glaciology Expert
JICA (Hokkaido Univ.)
Water and Energy Commission
Secretariat, P. O. Box 509
Kathmandu
Tel: 229699
Fax: 228111

15. Mr. Bharat Mani Jnawali
Senior Divisional Geologist
Department of Mines and
Geology, Lainchaur
Kathmandu
Tel: 411396

16. Dr. Dibya Ratna Kansakar
Sr. Divisional, Hydrogeologist
Ground Water Resources'
Development Project
Department of Irrigation
Babar Mahal, Kathmandu
Tel: 224953
Fax: 231979

17. Mr. Mohan P. Wagley
Director General
Depart. of Soil Conservation
Babar Mahal, Kathmandu
Tel: 220828
Fax: 225144

18. Mr. Madhukar Upadhya
Project Manager
Bagmati Watershed Project,
Depart. of Soil Conservation
Babar Mahal, Kathmandu
Tel: 233814

19. Mr. Lila Nath Tripathi
Senior Divisional Engineer
Department of Roads SBD,
Pulchowk, Kathmandu
Tel: 524631

20. Mr. Indu Sharma Dhakal
Senior Divisional Engineer
Geo-Environmental Unit
Department of Roads
Babar Mahal, Kathmandu
Tel: 231981
Fax: 231981

21. Mr. Govinda Sharma Pokharel
Chief, SRC Laboratory
Nepal Electricity Authority
Swayambhu, Kathmandu
Nepal
Tel: 271351
Fax: 278336

22. Dr. Chandra Kant Sharma
Academician & Visiting Prof.
RONAST & TU
Bijuli Bazar, Kathmandu
Nepal

23. Mr. Surya Bhakta Upadhyay
Director,
Multi Disciplinary Consultant
P. O. Box 5720, Kathmandu
Nepal
Tel: 525076
Fax: 523103

24. Mr. Ajaya Dixit
Chairman
Nepal Water Conservation
Foundation
P. O. Box 2221, Kathmandu
Nepal

25. Mr. Felix von Sury
Coordinator
Swiss Dev. Cooperation (SDC)
P. O. Box 113, Ekanta Kuna
Lalitpur
Tel: 524927/8/9
Fax: 525358

26. Mr. Patrick Kilchenmann
Hydrogeologist
SDC-N/SMO - Techn. Advisor
Ekanta Kuna, Kathmandu
Nepal
Tel: 524927
Fax: 525358

27. Mr. Tuk Lal Adhikari
Landslide Stabilisation Engg.
ITECO Nepal Pvt. Ltd.,
New Baneshwor, Kathmandu
Nepal
Tel: 222888
Fax: 227258

28. Mr. Achyuta Nanda Bhandary
Senior Geologist
ITECO Nepal Pvt. Ltd.,
New Baneshwor, Kathmandu
Nepal

29. Mr. Shyam Lal Vaidya
Hydrologist
ITECO Nepal Pvt. Ltd.,
New Baneswor, Kathmandu
Nepal
Tel: 476946/475946
Fax: 470551

30. Dr. Andre Pugin
University of Geneva
Department of Geology
ITECO Ltd (Geneva)
Tel: +41-22-7026611

31. Mr. Alexis Wagner
HMWA Project Leader
ITECO Eng. Ltd. (Switzerland)
Alte Obfelderstr. 68 8910
Affoltern a.A. Switzerland
Tel: 0041-1-7611745
Fax: 0041-1-7611720 (ITECO)
0041-22-7938203

32. Dr. Sandip Shah
Geotechnical Engineer
Shah Consult International (P)
Ltd., GPO Box 3840,
Kathmandu, Nepal
Tel: 471852
Fax: 471852

33. Mr. Birendra B. Deoja
Director General
Dept of Civil Aviation,HMG/N
Babar Mahal, Kathmandu
Tel: 227287
Fax: 222416

34. Mr. Adarsha Pokhrel
Deputy Director General
Department of Hydrology &
Meteorology, Babar Mahal
Kathmandu
Nepal
Tel: 226374
Fax: 224648

35. Mr. Om Ratna Bajracharya
Senior Divisional Hydrologist
Dept. of Hydrology and
Meteorology, Kathmandu
Nepal
Tel: 226374
Fax: 224648

36. Mr. Bishnu Das Shrestha
Senior Geologist
Depart. of Soil Conservation
Babar Mahal, Kathmandu
Nepal
Tel: 220828
Fax: 221067

ICIMOD
P.O. Box 3226
Jawalakhel, Lalitpur
Nepal

41. Dr. M. Banskota

42. Prof. S.R. Chalise

43. Prof. Li Tianchi

44. Mr. P.K. Mool

45. Mr. G. Nakarmi

46. Mr. I. Gyawali

Annex 3
Group Membership

Group 1: *Scientific Understanding of Glacial Quaternary Deposits*

1. Andre Pugin
2. Dibya R. Kansakar
3. Bidur Upadhya
4. S.R. Pant
5. D.P. Adhikari
6. Megha Raj Dhital
7. Narendra Raj Khanal
8. Shyam K. Manandhar
9. Li Tianchi
10. S. R. Chalise
11. C. K. Sharma
12. B. N. Upreti
13. V. Dangol
14. G. Rana

Group II: *Hazard Mapping and Soft Engineering*

1. P. Rohner
2. L.N. Tripathi
3. I.S. Dhakal
4. G. Nakarmi
5. B.M. Gyawali
6. O.R. Bajracharya
7. A.N. Bhandary
8. S.B. Upadhyaya
9. P. Kilchenmann
10. A. Wagner
11. H.K. Sainju
12 S.L. Vaidya
13. P.K. Mool
14. M. Upadhya
15. Li Tianchi
16. K.B. Thapa
17. A. Pandey

Annex 3
Group Membership

Group I: *Scientific Understanding of Glacial Quaternary Deposits*

1. Andre Pugin
2. Dibya R. Kansakar
3. Bidur Upadhya
4. S.R. Pant
5. D.P. Adhikari
6. Megha Raj Dhital
7. Narendra Raj Khanal
8. Shyam K. Manandhar
9. Li Tianchi
10. S. R. Chalise
11. C. K. Sharma
12. B. N. Upreti
13. V. Dangol
14. G. Rana

Group II: *Hazard Mapping and Soft Engineering*

1. P. Rohner
2. L.N. Tripathi
3. I.S. Dhakal
4. G. Nakarmi
5. B.M. Gyawali
6. O.R. Bajracharya
7. A.N. Bhandary
8. S.B. Upadhyaya
9. P. Kilchenmann
10. A. Wagner
11. H.K. Sainju
12 S.L. Vaidya
13. P.K. Mool
14. M. Upadhya
15. Li Tianchi
16. K.B. Thapa
17. A. Pandey

ICIMOD

Founded out of widespread recognition of degradation of mountain environments and the increasing poverty of mountain communities, ICIMOD is concerned with the search for more effective development responses to promote the sustained well being of mountain people.

The Centre was established in 1983 and commenced professional activities in 1984. Though international in its concerns, ICIMOD focusses on the specific, complex, and practical problems of the Hindu Kush-Himalayan Region which covers all or part of eight Sovereign States.

ICIMOD serves as a multidisciplinary documentation centre on integrated mountain development; a focal point for the mobilisation, conduct, and coordination of applied and problem-solving research activities; a focal point for training on integrated mountain development, with special emphasis on the assessment of training needs and the development of relevant training materials based directly on field case studies; and a consultative centre providing expert services on mountain development and resource management.

ICIMOD WORKSHOPS

ICIMOD Workshops are attended by experts from the countries of the Region, in addition to concerned professionals and representatives of international agencies. A large number of professional papers and research studies are presented and discussed in detail.

Workshop Reports are intended to represent the discussions and conclusions reached at the Workshop and do not necessarily reflect the views of ICIMOD or other participating institutions. Copies of the reports, as well as a Catalogue of all of ICIMOD's Publications, are available upon request from:

The Publications' Unit
International Centre for Integrated Mountain Development (ICIMOD)
G.P.O. Box 3226
Kathmandu, Nepal

Participating Countries of the Hindu Kush-Himalayan Region

- Afghanistan
- Bhutan
- India
- Nepal
- Bangladesh
- China
- Myanmar
- Pakistan

INTERNATIONAL CENTRE FOR INTEGRATED MOUNTAIN DEVELOPMENT (ICIMOD)

4/80 Jawalakhel, G.P.O. Box 3226, Kathmandu, Nepal

Telephone: (977-1) 525313
Facsimile: (977-1) 524509
(977-1) 524317

Telex: 2439 ICIMOD NP
Cable: ICIMOD NEPAL
email: pubs@icimod.org.np