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*NATURAL AND MAN-INDUCED SOIL EROSION, SAGARMATHA (MOUNT EVEREST) NATIONAL PARK, KHUMBU, NEPAL: A report on the activities of the UNU/MAB (Nepal) Mountain Hazards Mapping Project, Phase II

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Introduction

The degradation of the Himalayan environment, supposedly a consequence of contemporary deforestation and overgrazing, is a much publicized though poorly understood phenomenon. The past decade has produced a copious literature linking population pressures with increased deforestation, soil erosion, landslides and siltation of water courses (e.g., Eckholm 1975a, 1975b, 1976; Sterling 1976; Rieger 1976). The Kingdom of Nepal has been frequently cited as a prime example where the above factors have resulted in widespread environmental degradation. These assumptions, supported by little reliable data, have nevertheless provided the basis for many on-going development policies in the Himalaya (Thompson and Warburton 1985a; Ives 1984).

In 1984, the United Nations University (UNU) funded a 9 month project in the Sagarmatha (Mount Everest) National Park of Nepal with the specific objective of quantifying natural and man-induced rates of soil erosion, thereby removing some of the uncertainty surrounding the aforementioned assumptions in at least one Himalayan region. The project represents the geoecological component of the Mountain Hazards Mapping Project, Phase II (Khumbu), with the actual hazard mapping fieldwork completed in 1982 by colleagues from the University of Berne (Ives and Messerli 1981). Sagarmatha National was chosen to represent the High Mountain study region because of reportedly high man-induced soil erosion rates; the availability of relevant literature; and access to maps and aerial photographs.

Members of the expedition included Alton Byers (team leader); Elizabeth Byers (geohydrologist); Khadga Basnet (ecologist); Narendra Raj Khanal (cultural geographer); Khancha Lama (field technician); and Pemba Sherpa (headquarter/field assistant). Dr. Colin E. Thorn (Department of Geography, University of Illinois) assisted the team with its start-up activities in March, 1984. Dr. J.D. Ives (Department of Geography, University of Colorado) and Professor S.R. Chalise (Member Secretary, MAB/Nepal) provided valuable moral, technical and material support throughout the project's duration.

Objectives

In addition to the soil erosion monitoring work to be described here, project staff collected detailed information in various complementary disciplines including forestry, botany, soils, hydrology and human ecology (e.g., local fuelwood requirements, tourist impacts, etc.). Collectively, it is anticipated that the above data will provide answers to the following critical questions:

(1) What are the natural and man-induced surficial erosion rates, between sites of differing elevations/aspects/vegetative cover, in the Sagarmatha National Park?

(2) How do "natural" and "man-induced" rates of erosion compare in terms of total erosion, sediment delivery ratio and sediment yield?

(3) How extensive has landscape degradation been in the Park over the past 30-50 years; what are its causes, and what role has this played in the assumed problem of increased soil erosion?

(4) How do the results of the project compare with past findings in the allegedly "over-researched" Khumbu region, and what are the implications concerning current and future project planning in the Khumbu and elsewhere in the Himalaya?

Research Design

The attempts to quantify absolute and comparative rates of surficial soil loss were undertaken throughout the monsoon season of 1984 (approximately April-October). Thirty-six study plots were arrayed in a stratified, replicated design that permitted comparison between (1) north-facing forest

(Abies spectabilis/Betula utilis/Rhododendron sp.), (2) south-facing scrub-grassland (Cotoneaster microphyllus/R. lepidotum/ grass-forb, and (3) variations in elevation ranging from Namche Bazaar (3440 m) to Dingboche (4412 m).

Preliminary plot work included the determination of aspect and elevation, slope profiling (50 m), plot profiling (5 m), and the installation of instruments and hardware. All instruments were situated within a 5m x 5m area and consisted of a raingauge, plastic sediment trough (50 cm x 10 cm x 5 cm), erosion pins, and two sets of painted marker pebbles. Ground cover was determined for each plot by direct measurement at the time of installation, and seasonal vegetation changes assessed on adjacent 400m2 quadrants using a point-intercept method (800 points). Between two and three plots were situated at each stratified monitoring site. Eighteen soil pits, each representing a major slope/aspect/vegetation stratification, were excavated and detailed field observations noted. All of the above items represent fairly standard geoecological methodologies, separately discussed in greater detail by Carson and Kirkby (1972); Thorn (1982); Bovis (1975, 1978); Morris (1983); Goudie et. al. (1981); Haigh (1977); Phillips (1959); and Daubenmire (1968).

All plots were monitored on a weekly basis with the following information recorded:

Date	Soil capillary pressure
Time of monitoring	Air temperature
Weather notes	Unconfined shear strength of surficial soil
Plot description (vegetation, disturbance changes)	Marker pebble movements
Precipitation	Erosion pin measurements
Sediment accumulation	Soil temperature

Three south-facing scrub-grassland and two north-facing forest plots in the vicinity of the Khumjung headquarters were monitored for precipitation and sediment accumulations after each period of rainfall. Rainfall intensities were calculated at the Khumjung station after approximately 38 storm events. Seventeen years of climatological records for the Khumbu region should provide adequate insights regarding the representativeness of the 1984 monsoon data.

Field Samples

Erosion plot samples collected which now require laboratory analysis include (1) 108 accumulated sediment samples from the plot troughs (576 total reduced to 3 per side -- early, mid- and late monsoon), (2) 36 surficial "source region" samples (material collected 1 m upslope from each trough at the season's end), and (3) 180 soil profile samples (540 total reduced to approximately 10 per profile). Other complementary samples obtained include over 2000 tree increment cores (forest dynamics studies), 2500 plant specimens (500 species), alpine/subalpine plant seeds (200 species), 10 lakebed sediment cores (pollen analysis), and 10 charcoal samples from buried soils (historical climatic change). Repeat photography of Erwin Schneider's 1950-60 landscape photographs was obtained (recent land-use change analysis), a wood consumption survey covering 6 Khumjung households conducted (3 month survey period), and 6 permanent river gauging stations within the Imja Khola watershed installed and monitored for a period of one year. These items represent only the core of samples and data collected by the project over the 9 month field season, but collectively their analysis should suffice to fulfill the overall project objectives previously mentioned.

Anticipated Laboratory Analysis Techniques and Products

Considerable laboratory work will be necessary in order to provide much of the raw data required for subsequent analysis of the soil erosion, forestry and land-use components. Requests for funding are currently being circulated, and it is hoped that the bulk of the laboratory work will commence by late fall, 1985.

Soil samples collected from the sediment troughs and "source regions" will be analyzed for particle size, organic content and pH. This will enable an assessment of sediment volume, source, composition and seasonal fluctuations. Significant differences between mean erosion rates at varying elevations/-aspects/vegetative cover sites will be assessed through simple statistical tests, such as Chi-square or student's t. The potential correlation between erosion rates and soil, climate, land use and other parameters will be determined through multiple regression analysis. Soil profile samples will be analyzed for particle size, organic content and pH, then classified into major soil groups utilizing detailed field notes and profile photographs. A soil map of the project region will be produced.

Detailed forest structure information from the 2000+ tree increment cores will be obtained. Simple counting of all increment core rings, a labor-intensive activity, is necessary for this component. A large amount of additional information (species composition, disturbance assessments, forest structure, wood volume) can be obtained through the analysis of extensive field notes and simple statistical techniques of frequency distribution, curve-fitting to standard forest structural models and linear regression and correlation analysis. Detailed vegetation maps from the above and other vegetation work will then be made. Historical and contemporary vegetation change information will result from C14 analysis of buried charcoal deposits; pollen counts from the lakebed cores, with results compared to the work of other recent analysis efforts (Brower, 1985, personal communication); and comparisons (possibly computer-assisted) of old and recent landscape photography.

Estimates of village fuelwood requirements will be calculated based upon months of actual fuelwood weight, volume, moisture content, species and harvesting region information. Detailed hydrological data (discharge, temperature, and suspended load characteristics of the Imja Khola and tributaries; groundwater distribution, flow and basin response to rainfall) will be processed and could be of particular use to planners and alternative energy specialists.

Certain project components not requiring funding are already at advanced stages of completion. For example, over 90% of the 2500 plants collected (donated to the University of Colorado Herbarium) have been identified and entered upon a computer spread-sheet format capable of sorting by elevation, location and date of collection. The plant list is scheduled for publication by the British Museum (Miehe, 1985, personal communication); and approximately 150 alpine/subalpine plants are currently growing at the Denver Botanical Garden and 27 other seed-recipient botanical gardens in the U.S. and abroad (Kelaides, 1985, personal communication).

Preliminary Results

In the absence of the final data analysis it is not possible to provide a definitive statement at this time. However, a brief examination of certain preliminary findings may be of interest in relation to the questions previously mentioned:

(1) Most major landscapes within the study region, and beyond to the upper summer pastures, have been extensively modified by the activities of man. Vegetation communities reflect this disturbance primarily via the (a) heavily terraced south-facing slopes with their high percentages of shrub species, and (b) the high percentages of Rhododendron spp. apparently invading many north-facing forests.

(2) Not all sites appear to have suffered the accelerated erosion attributed to "overgrazing" and "deforestation" within the Khumbu region. Mass wasting on many terraced south-facing slopes, for example, appears to be held in check by the thick shrub species (Cotoneaster microphyllus, R. lepidotum) which usually grow on the terraced risers. Forests, while often heavily grazed, are not lopped for fodder and contain a thick groundcover of litter on a year-round basis. Both regions may experience a significant increase in herbaceous groundcover by the onset of the heaviest monsoon rains (mid-July), which can further retard downslope soil movement.

(3) Soil erosion rates appeared to be negligible for most south-facing pasture and all north-facing forest plots. The notable exceptions were the above-treeline plots in the summer pasture region of Dingboche (4412 m). Within this sensitive, high altitude ecosystem, grazing and continued harvesting of shrub Juniperus sp. for local and tourist fuelwood needs have, in general, created much more severe levels of landscape degradation than those found at lower elevations. While better management policies may be required for the forests and grazing regions below 4200 m, strict land-use policies for certain regions above 4200 m will be necessary to prevent further environmental degradation and, concurrently, loss of grazing- and tourist-related income.

(4) The preliminary findings of the 1984 Mountain Hazards Mapping Project differ considerably from the many reports of the Khumbu region emphasizing widespread overgrazing, deforestation and increased soil erosion rates (e.g., Furer-Haimendorf 1975, 1984; Blower 1972; Mishra 1973; Speechly 1976; Lucas et. al. 1974; Cooper 1974; Rushton 1978; Sherpa 1978; Bjonnes 1983; Joshi 1982; Andrews 1983; Thompson and Warburton 1985a, 1985b). It is possible that many factors, including the (1) nature of short-term research, (2) development project policies, (3) adherence to popular, generalized predictions, and (4) the fostering of a "crisis" mentality in order to motivate funding agencies, project personnel and tourist behavior, may have influenced many of these previous studies. Common to most, however, is the lack of quantifiable data to support the claims made.

(5) It is hoped that the Mountain Hazards Mapping Project can demonstrate the importance of longer-term, quantifiable geoecological research to the understanding of mountain environments and development of better land-use variability. Future, replicated studies within the Khumbu and other

mountain regions are indicated for the most accurate understanding of the many interactive systems at work.

Concluding Remarks

Largely because of their many valuable contributions in the field, Messrs. Khanal and Basnet have recently been awarded UNU Fellowships for a period of one year at the University of Colorado, Boulder, Colorado. In addition to pursuing relevant coursework, it is anticipated that they will participate in the laboratory and data analysis components of greatest interest to their individual disciplines. They will join 3 other UNU Fellows from Bhutan and the People's Republic of China involved with similar geoecological studies and projects (Ives and Messerli 1984; Ives 1985; Byers 1985).

Finally, the author would greatly appreciate hearing from those with comments concerning the project in general, and specifically ideas related to (1) the proposed laboratory and data analysis techniques and (2) alternative applications and recipients of the resultant data (e.g., HMG and donor agency development projects in Nepal and elsewhere in the Himalaya).

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*TYPESET INDIC CHARACTERS FROM WORD PROCESSOR FILES: PART I

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The complexion of typesetting has been changing of late. It is possible, using a personal computer or dedicated word processor, to create a file of text which may be sent via telecommunications equipment to commercial phototypesetters. Roman typeset text is produced, usually within 24 hours of the time the vendor receives it over the telephone lines, for $2.00 per thousand characters. While the price is low, one still has available a wide range of typefaces (typically over 100), type sizes ranging from the tiny to those large enough for an eye-chart, italics, elaborate borders, and more.

What these changes portend should be clear for those in South Asian studies -- for anyone who has ever struggled with the trans-oceanic falderal necessary to complete even rudimentary typesetting in Indian languages, or for those who have been forced to settle for the low quality of typewritten Indian characters in a publication or in classroom materials. This first portion of a two part article provides an overview of the equipment involved, describes developments in the photocomposition of Indian characters, and outlines the current state of services available in North America. The second part of the article will offer details on vendors who provide typeset Indian characters from computer files transmitted to them over the telephone, samples of the type they make available, an assessment of the quality of their services, and a consideration of some significant but less obvious implications for South Asian studies arising out of these new capacities.

The Equipment

Under the rubric of photocomposition (the use of projected light to set type characters on light-sensitive paper) there are two different varieties of machines. The older variety employs negative film images of the characters which are projected onto photographic paper. The other type of machine uses computer control to store characters, in digital form, in the memory of the processing unit and eventually to project them by laser on to paper. The latter, newer hardware is generally more suited to the demands of work with India's regional scripts since those alphabets require more characters and conjunct combinations than will comfortably fit into the standard film fonts in older machines. With the newer equipment -- known as third generation machines -- aesthetically pleasing results may be achieved for complicated conjuncts by storing them in memory as discrete units, yielding type fonts of over 500 members for some regional languages.

Equipment for keyboard entry and telecommunications can be as simple as an inexpensive personal computer and slow speed modem (modulator and demodulator for telephone transmission of computer data). It may be as involved as a dedicated word processor or commercial photocomposition video display terminal and a high speed modem. Nevertheless, the end result, from the perspective of the phototypesetting equipment, will be virtually identical. As for the software, preparation of the text itself may be accomplished with any good word processing program. Other customized software is available inexpensively from some phototypesetting vendors, which allows for transmitting text and checking for errors in the special control codes (those used to invoke indentation, a change of type style or size, and so forth).

Photocomposition Developments in India

The Institute of Typographical Research (ITR) in Pune is one of the forces propelling developments in the burgeoning area of photo-composition. Since 1978, ITR has worked with various manufacturers (Autologic, Linotype, Compugraphic, Alphatype, and several others) preparing keyboard layouts, hyphenation rules for Indian languages, dot matrix designs for use on video display terminals, and type fonts of both the film and digital varieties. Last year they finished work on Telegu with the result that all ten of the major Indian scripts are now available, at minimum, in both a light and a bold face for photocomposition equipment. In addition, ITR has also prepared fonts for Thai and Sinhala.

Monotype India of Bangalore has also been developing fonts for Indian regional language scripts in conjunction with the British parent, Monotype. As of the summer of 1983, they had adapted Monotype equipment for use with Devanagari, Gujarati, Bengali, Tamil, Telegu, and Kannada.

In Delhi, the Department of Electronics in the Government of India has established a sub-committee on "Standardization of Indian Scripts and Their Codes for Information Processing." As a parallel to ASCII (American Standard Code for Information Interchange, a standard for computer processing which represents each letter and symbol in the form of a numerical code) they have begun to propose a standard called ISCII (Indian Script Codes for Information Interchange).

Additionally, vendors of computerized phototypesetting services are beginning to appear in India. Typographica is one example in Pune, across Law College Road from the Bhandarkar Oriental Research Institute. The owner, V.V. Belwalkar, is currently only able to provide typesetting in Roman characters. He does have plans, though, for expansion into Devanagari composition in the near future.

Indian Scripts on American Machines

The current state of affairs is not particularly good. While most of the major manufacturers of phototypesetting hardware in this country claim to support at least some scripts from India (usually Devangari is one of them), there are several companies which have not sold a single font to a North American typesetting agency. In fact, one manufacturer informed me that even though they advertise the availability of Devanagari, they have yet to complete the final computer programs which will allow it to operate on their equipment. In another case an American university purchased a Devanagari font for its typesetting equipment only to find that the software which accompanied it was not properly prepared and that the manufacturer was not able to make the necessary adjustments. The font still has not been used.

If one wants to prepare text on a remote computer system and transmit that material to a typesetter via telecommunications, there are few if any companies which will presently handle the job. (There are, on the other hand, numerous companies which will take on phototypesetting jobs in Indian regional languages. But they insist on handling the keyboard work which dramatically increases cost and reintroduces the same typographical error problems which the use of a personal computer was intended to remedy.)

The difficulties are not at the level of the hardware since that is already available. The type fonts themselves also exist for all the major Indian scripts. Further, the telecommunication of data from personal computers to photocomposition equipment is well established in this country, at reasonable prices, for Roman texts.

The only thing which is lacking is for photocomposition vendors to place the pieces together and allow for low priced, high quality composition of Indian texts in this country. I am currently exploring a solution to this logistical problem with several North American vendors and, simultaneously, attempting to assess the state of affairs in Europe. The results will be described in the second part of this article. In the meantime, the experiences of others with computerized photocomposition in Indian regional language scripts is solicited.

Reading Suggestions

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(Reprinted from South Asia Library Notes & Queries, No. 17, October 1984)

*DUMAKHAL EXCAVATION: A PRELIMINARY REPORT

Background

Dumakhal is a small village located near the banks of the Manohara river, not far from the hill of Changu Narayan. Surface evidence from the village and its surroundings indicated a possibly rich archaeological site. Random finds included stone tools, arrowheads, a bronze bowl, Licchavi coins, and terracotta figures. The entire area even now is strewn with bricks and potsherds. All this evidence led to a more systematic surface exploration in July 1983.

In January 1984, a small single trench was laid out, and excavation begun. In view of the approaching monsoon the dig was closed and reopened in early October 1984. The trench was slightly expanded and divided up into several quadrants. The entire excavation work has been documented in drawings and photographs. Drawings of structures, interesting objects and stratigraphic sequence have been made. Soil samples from different stratigraphic layers have been sent for laboratory analysis.

Digging at the site was carried out by Mr. Mohan Khanal with due permission from the Department of Archaeology, HMG. CNAS granted him a leave-with-pay to work at the excavation. Prof. Prayag Raj Sharma and Prof. Theodre Riccardi, Jr. collaborated with the principal investigator in his excavation work as advisors, and the dig was financed entirely from private non-institutional sources.

Preliminary Findings

According to the preliminary report, the more important of the finds include:

1. Two parallel north-south running walls of bricks and rough stones, probably belonging to two different periods.

2. A huge quantity of potsherds of different fabric, shape and design. Particularly important finds include pieces of stamped pottery of many designs, mainly from the third and fourth layers.

   Preliminary consultation with archaeologists in India seemed to suggest a pre-Gupta date of these stamped pottery. They may be comparable to some pottery types found from Ahichhatra. The chronology of the pottery is, however, yet to be firmly determined.

3. Terracotta human and animal figures; bangle pieces of glass, stone beads, a Mananka coin.

4. Burnt or unburnt animal bones, charred grains in some quantity, and some charcoal. A sample of charcoal, collected from the site has been sent for carbon-14 analysis to the Physical Research Laboratory at Ahmedabad, India.

5. The study of the objects and the structures laid bare in course of the dig will be made in relation to the layers in which they were found, and a possible date for these different layers will be estimated.

A further report is being prepared, and when published, will be available to all interested persons for a closer and objective scrutiny. An exhibition of the more interesting finds is also being considered.

(From CNAS Newsletter, Spring, 1985)

*STUDY ON THE CRUSTAL MOVEMENTS IN THE NEPAL HIMALAYAS

Introduction

The field investigations on the "Study on the crustal movements in the Nepal Himalayas" (CMH) were carried out under the leadership of K. Kizaki in 1982-83 as the continuance of the CMH 1980 with the permission and cooperation of His Majesty's Government of Nepal. The reports of the CMH 1980 was published as a special issue of the Journal of Nepal Geological Society in 1982. The 1984 special issue of the Journal of Nepal Geological Society also contains the results of the field surveys and laboratory works in the Nepal Himalayas on the geology and geomorphology as well as the geomagnetism and pollen analysis conducted by the members of the CMH 1982.

Field Surveys and Results

The field surveys were carried out from October 1982 to January of 1983 in central and western Nepal and were divided into three groups as follows: 1) Basement geology, 2) Neogene Tertiary and Quaternary geology, 3) Geomorphology.

1) Basement geology. The surveys on the basement geology were carried out mainly in western Nepal, and the investigators have been able to further our knowledge of geology in this part of the Nepal Himalayas. Arita and his group have been able to establish firm correlation of the Jajarkot klippe with the Jajarkot-Arkha crystalline, and further to the south, the lower part of Fuchs' Chail nappe has been recognized under the Jajarkot klippe. Hayashi and his co-investigators have elucidated the geology of the Karnali region; the Karnali klippe has been separated from the Almore nappe of Kumaun, and the existence of the Chail nappe under the klippe has been questioned. Sakai studied the Tansen area in west Nepal, and points out the lack of Infra Krol and Krol (of India) in central and western Nepal. Yoshida and Sakai find that the paleomagnetic data from the Tansen group (Paleozoic to early Cenozoic) are consistent with those from India, Pakistan and the southern side of the Yarlung Zangbo River. Kano concludes that the augen gneisses of the MCT zone resulted from tourmaline granite which has been sheared and blastomylonitized due to the MCT movement on the basis of many observations in western, central and eastern Nepal.

2) Neogene Tertiary and Quaternary geology. Tokuoka and Yoshida present a progress report on the study of the Churias (Siwaliks) in central Nepal though there are new discoveries of molluscan fossils and some results on paleomagnetism to suggest the ages. Significant results of the geohistory of the Kathmandu Valley since Pliocene are revealed by Yoshida and Igarashi using the data of Paleomagnetic measurements, radiometric dating and pollen analysis. Yoshida et al. also describe the magnetostratigraphic and pollen analytic results in the Takmar series of the Thakkhola graben in central Nepal.

3) Geomorphology. Iwata et al. suggest that the Midlands and Mahabharat range have been uplifted as much as 1,000 to 2,000 m in altitude in the past several million years and may continue up to the present owing to the upwarping process rather than the vertical block movement. Yamanaka and Yagi show the formation of the Dang Dun south of the Mahabharat range in western Nepal resulting from the upwarping of the Churia range succeeded from the Mahabharat uplifting. Nakata et al. stress the recent crustal movement of the frontal zone of the Sub-Himalayas. Lastly, Mezaki and Yabiku describe the deposition and classification of the present river bed gravels so that the mode and volume of the transportation of materials by the Kali Gandaki is clarified.

Some of the reports and the investigations in the laboratory and field are still in progress. However, the crustal movement in the Nepal Himalayas since Paleozoic time is becoming clear on the basis of various geological and geomorphological evidences particularly the recent crustal movements of the Sub-Himalayas. These findings are presented in the special issue of the Journal of Nepal Geological Society (Vol. 4, 1984).

The members of the CMH 1982 are as follows:

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For Table of Contents of this journal, see Publication and Film News.)