

**MOUNTAIN ENVIRONMENTAL MANAGEMENT IN THE
ARUN RIVER BASIN OF NEPAL**



John R. Dunsmore

ICIMOD OCCASIONAL PAPER No. 9

**Kathmandu, Nepal
December 1988**

ICIMOD Occasional Papers

No. 1

EROSION AND SEDIMENTATION PROCESSES IN THE NEPALESE HIMALAYA

Brian Carson

August 1985.

No. 2

INTEGRATED RURAL DEVELOPMENT PROJECTS IN NEPAL: A REVIEW

Bharat B. Pradhan

December 1985.

No. 3

**SUSTAINING UPLAND RESOURCES: PEOPLE'S PARTICIPATION IN
WATERSHED MANAGEMENT**

Anis Ahmad Dani and J. G. Campbell

July 1986.

No. 4

**DECENTRALISED ENERGY PLANNING AND MANAGEMENT FOR
THE HINDU KUSH-HIMALAYA**

Deepak Bajracharya

September 1986.

No. 5

GLACIAL LAKE OUTBURST FLOODS AND RISK ENGINEERING IN THE HIMALAYA

Jack D. Ives

November 1986.

No. 6

**OPERATIONAL EXPERIENCES IN FOREST MANAGEMENT DEVELOPMENT
IN THE HILLS OF NEPAL**

G.B.Applegate and D.A.Gilmour

January 1987.

No. 7

FORESTRY - FARMING LINKAGES IN THE MOUNTAINS

T.B.S.Mahat

March 1987.

No. 8

**ROAD CONSTRUCTION IN THE NEPAL HIMALAYA:
THE EXPERIENCE FROM THE LAMOSANGU - JIRI ROAD PROJECT**

Urs Schaffner

March 1987.

No. 9

MOUNTAIN ENVIRONMENTAL MANAGEMENT IN THE ARUN RIVER BASIN OF NEPAL

John R. Dunsmore

December 1988

**MOUNTAIN ENVIRONMENTAL MANAGEMENT IN THE
ARUN RIVER BASIN OF NEPAL**

John R. Dunsmore

ICIMOD OCCASIONAL PAPER No. 9

**Published by
International Centre for Integrated Mountain Development
Kathmandu, Nepal**

Copyright©1988

International Centre for Integrated Mountain Development

All rights reserved

Cover Photograph: Farming landscape in Chungbang Village Panchayat. Dhankuta Town and the final stretch of the Dharan-Dhankuta road in the middle distance.

Published by

International Centre for Integrated Mountain Development, in association with
Kefford Press Pte Ltd, Singapore

G.P.O.Box 3226, Kathmandu, Nepal

ISBN 981-00-0925-9

The views and interpretations in this paper are the author's and are not attributable to the International Centre for Integrated Mountain Development (ICIMOD), and do not imply the expression of any opinion concerning the legal status of any country, territory, city or area of its authorities, or concerning the delimitation of its frontiers or boundaries.

TABLE OF CONTENTS

	Page
SUMMARY	i
ACKNOWLEDGEMENTS	iv
PART I. THE ARUN RIVER BASIN	1
Hydrology, Climate, Geology and Land Capability	1
Population - past, present and projected	8
Communications - access by foot-trail and road	11
Vegetation - a unique diversity and key indicator of change	14
Land Use	20
Land Tenure - legal and perceived	21
Farming Systems - agro-ecological variations within a basic system	24
Off-farm Economic Activities	30
- alternative, complementary and supplementary income generation	
Arun-3 Hydro-Electric Scheme and Access Road	34
Government Administration	40
PART II. INCREASING THE EFFECTIVENESS OF THE ENVIRONMENTAL MANAGEMENT SYSTEM	45
Introduction	45
The Resource Base - Preparation and Maintenance (Geographic Information System)	45
Development Planning - Perspective and Annual - Prioritisation	47
The Community or "User Groups"	48
Woman - The Neglected Familiar	50
Conservation - Southern Zone	56
- Northern Zone	58
Zonal Activities	60
REFERENCES	62
THE AUTHOR	66

LIST OF ILLUSTRATIONS

	Page
TABLES	
1. Climatic types	3
2. Areas of soil depth/slope categories: Koshi Hill Districts	8
3. District populations 1952, 1971 and 1981	10
4. Areas of forest types by District - Southern Zone (1978) in hectares	14
5. Recommended fodder tree species	16
6. Altitudinal zones of grasslands and their successional types	19
7. Arun River Basin - Southern Zone: Land use types (ha) - by District	20
8. Land use percentages - Southern Zone - by District	21
9. Land use types - Northern Zone - by sub-catchment	21
10. Southern Zone - Cropping patterns and calendar	24
11. Arun River Basin - livestock numbers 1982	25
12. Arun River Basin - Livestock numbers 1986/87	26
13. Summary - Population per km ² of agricultural land by Village Panchayat	27
14. Village Panchayats with population densities per km ² of agricultural land exceeding 400	28
15. Koshi Hill Districts: Land available for cultivation per household	28
16. Fragmentation of land holdings - number of parcels/holding: percent	29
17. Arun River Basin: Agencies involved with environmental management	41
18. Time use by men and women (Age 15+). Hours per day between 0400 and 2000	50
19. The respective contributions (%) by men and women to household income: Pangma, Sankhuwasabha	51

TEXT MAPS

1.	The Arun Study Area And Communications	ii
2.	The Arun River And Its Main Tributaries Within Nepal	2
3.	The Arun River Basin In Tibet And Nepal	4
4.	Physiographic Representation Of The Arun River Basin, Nepal	9
5.	Income Generating Activities In The Arun River Basin	32
6.	Arun-3 Access Road Alignment	35
7.	Physiographic Divisions Of The Koshi Zone	57

FIGURES

1.	Monthly Rainfall At Representative Stations	6
2.	General Pattern Of Grassland Succession	18
3.	Agriculture, Forestry And Livestock Inter-relationship	23

PLATES

FARMING LANDSCAPES

12 - 13

1. The Arun river south of Hedangna, with area of mixed hardwood forest (T B Shrestha)
2. Besinda, Sankhuwasabha
3. Boya, Bhojpur
4. Transhumant stock husbandry above 3 000 metres, Milke Danda (T. B. Shrestha)
5. Livestock in the Middle Hills - land cultivation
6. Terraced crop production

COMMUNICATIONS

42

7. Foot-trail
8. Road construction, Hile - Basantapur

ROLES OF WOMEN

54

9. Collection of firewood and water
10. Hand milling food grain

ABBREVIATIONS AND ACRONYMS

ADBN	Agricultural Development Bank of Nepal
ADB	Asian Development Bank
ATS	Agricultural Technical School
CBS	Central Bureau of Statistics
DP	District Panchayat
FAO	Food and Agriculture Organisation (United Nations)
GIS	Geographic Information System
HMGN	His Majesty's Government of Nepal
ICIMOD	International Centre for Integrated Mountain Development
IRDP	Integrated Rural Development Programme
KHARDEP	Koshi Hill Area Rural Development Programme
LDO	Local Development Officer
LRDC	Land Resources Development Centre (now the Land Resources Department of the Overseas Development Natural Resources Institute, London)
LRMP	Land Resource Mapping Project
NEA	Nepal Electricity Authority
MFSC	Ministry of Forests and Soil Conservation
MPLD	Ministry of Panchayat and Local Development
ODA	Overseas Development Administration (United Kingdom)
PAC	Pakhribas Agricultural Centre
WECS	Water and Energy Commission Secretariat
WSCC	Women Service Coordination Committee
WTC	Women's Training Centre

Acknowledgement

ICIMOD acknowledges with thanks the generous support to this study from the International Development Research Centre of Canada (IDRC) which assisted both the field work in the Arun River Basin and the publication of this report. IDRC, of course, is not responsible in any way for the views expressed.

Summary

Statements on the fragility of Himalayan ecosystems, environmental degradation, particularly forest loss, resulting from a rapidly rising human population over-exploiting resources, and the danger of much of the rich biological diversity of the Hindu Kush-Himalayan region being destroyed, with the loss of unique species which could have made valuable contributions to the well-being of man and the environment, are liable today to sound almost like clichés. Nevertheless, it is against a background encapsulated in such statements that development in the Region must take place. The Arun River Basin study attempts to present a comprehensive account of the present situation in a specific area. On the basis of experience to date to achieve development without imperilling the very resources on which it depends, a number of suggestions are put forward as a contribution to discussions on ways of improving environmental management in such areas.

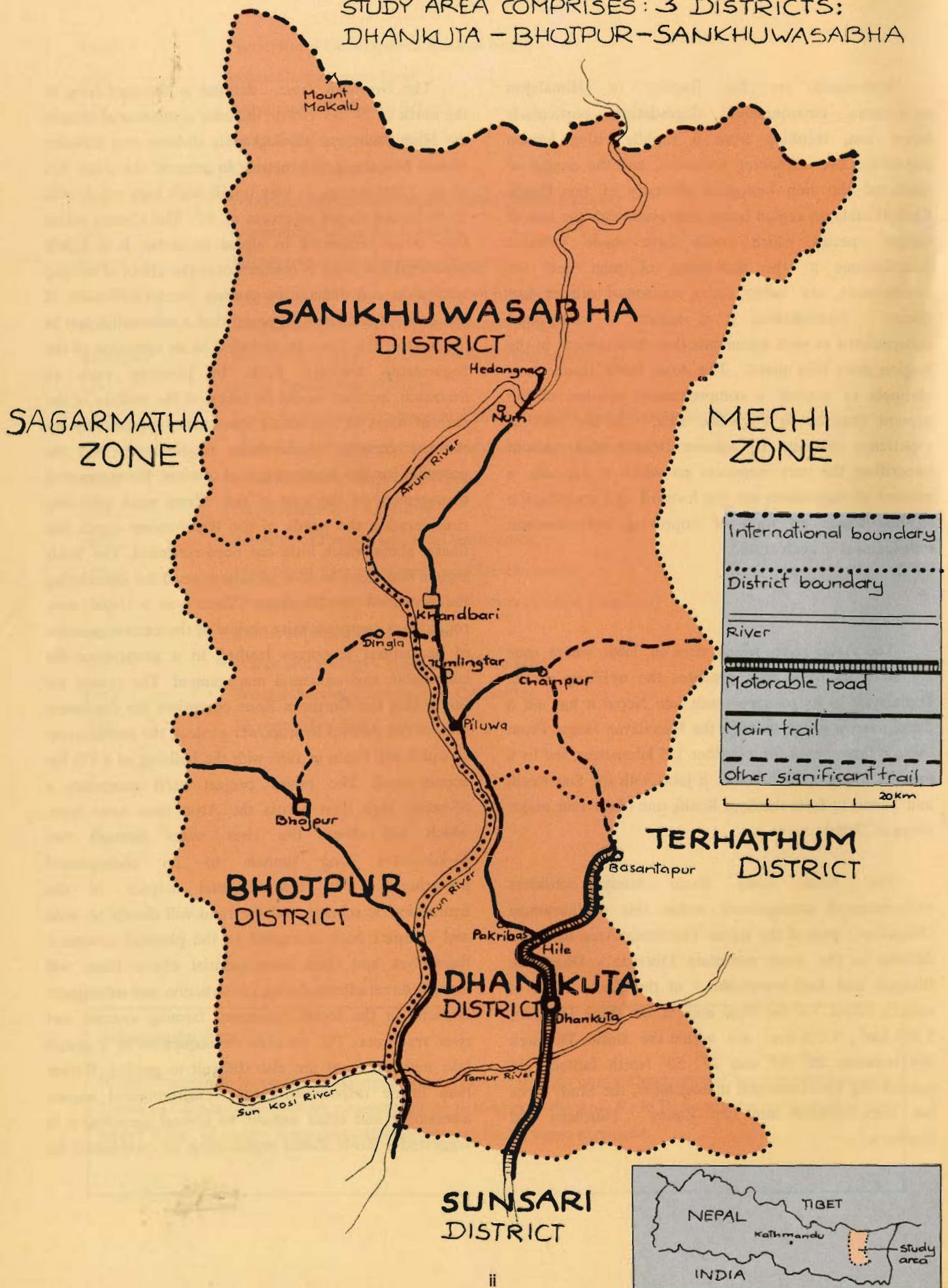
The Arun river, which rises in Tibet where over 80 % of its basin lies, predates the uplifting of the Himalayas: in its passage south into Nepal it has cut a deep, narrow gorge through the Himalayan range. From there it flows south for a further 155 kilometres, fed by a number of tributaries, before it joins with the Sun Koshi and Tamur to form the Sapt Koshi, one of the four major rivers of Nepal.

The Arun River Basin Study considers environmental management within this southernmost (Nepalese) part of the Basin. The Study Area has been defined as the three mountain Districts - Dhankuta, Bhojpur and Sankhuwasabha - of the Koshi Zone of eastern Nepal. Of the total area of the three Districts, 5 953 km², 5 028 km² are within the Basin. The area lies between 26° 50' and 27° 50' North latitude. In considering environmental management, the Study Area has been divided into two Zones - Northern and Southern.

The Northern Zone, defined as the part lying to the north of 27° 33' North, includes a substantial area in the High Himalaya physiographic division and includes Mount Makalu, 8 474 metres. In general, the Zone lies above 2 500 metres, is very fragile with high relief, over 73 % having slopes in excess of 40°. The climate varies from moist temperate to alpine to arctic. It is lightly populated but there is concern over the effect of shifting cultivation and damage by grazing livestock in parts of the Zone. It has been proposed that a substantial part in the west of the Zone be included in an extension of the Sagarmatha National Park. In planning such an extension, account would be taken of the welfare of the current users of the area's resources (particularly for summer grazing), conservation requirements and the potential for the development of tourism. Environmental management in the east of the Zone must take into consideration the needs of the transhumant herds and flocks, about which little has been recorded. The Study argues that there is now an urgent need for considering the whole of the Northern Zone as a single area, requiring a comprehensive review of the current position of its natural resources leading to a programme for sustainable environmental management. The reason for this is that the Northern Zone comprises the catchment area of the Arun-3 hydropower project, the construction of which will begin in 1989 with the building of a 170 km access road. The power project itself comprises a 65-metre high dam across the Arun river near Num, which will divert the river water through two 11-kilometre long tunnels to an underground powerhouse. The environmental impact of the hydro-electric scheme and the road will clearly be wide and complex both in regard to the physical structures themselves and their consequential effect: these will include direct effects during construction and subsequent impacts on the forest resources, farming systems and river resources. The possible consequences of a glacial lake outburst flood are also difficult to predict. Rather than divide responsibility for environmental impact assessment and other aspects to several agencies, it is suggested a Koshi Zonal organisation be established: its

TEXT MAP I: ARUN STUDY AREA AND COMMUNICATIONS.

STUDY AREA COMPRISES: 3 DISTRICTS:
DHANKUTA - BHOJPUR - SANKHUWASABHA



possible functions are listed below.

The Southern Zone, predominantly High and Middle Mountains, is, by contrast, heavily populated. Most of the people live dispersed on the hillsides at altitudes between 300 and 2 200 metres. The agro-ecological conditions vary greatly with altitude and aspect. The climate ranges from hot, dry subtropical to cool, moist temperate. The principal economic activity continues to be traditional mixed farming. The farming system employed varies with the agro-ecological conditions but all involve arable crop production on terraced hillsides. Most crop production is rainfed and the maintenance of soil fertility depends on organic manures obtained from the local forest/scrub resources or via livestock. Forest and livestock products are also important contributors to the household economy. The farming system can only be sustained if there is an adequacy and appropriate balance of the household's resources of arable land, livestock and forest / grazing area. The current situation gives rise to concern because:

- a. mean population per square kilometre of arable land is already very high, between 200 and 399 in 94 % of the Village Panchayats;
- b. pressure on land is exacerbated by the skewed distribution, with 43 % of households (5-7 people) having less than 0.5 ha available to them and 15 % controlling 44.4 %, including much of the better land;
- c. cropping intensities are already high - 133-250 % - and the potential for increasing the area under irrigation is very limited;
- d. it has been calculated that, with traditional levels of management, the maintenance of fertility of the arable land requires a ratio of arable to forest/scrub/grassland of 1:3 to 1:6. On average, it is now 1:2.5;
- e. while there is uncertainty over the actual number of livestock in the Southern Zone, it is known that fodder resources are inadequate in the latter part of the dry season;
- f. 27 % of the Southern Zone is covered by

unmanaged, over-grazed pasture, *Eupatorium* spp or forest with a canopy closure of 20-50 % - all of which indicate over-exploitation;

- g. the management of much of the forest/scrub/grassland areas - 40-50 % of the total area - is legally the responsibility of the Forest Department but in practice they are essential resources for the maintenance of the farming systems;
- h. little or no soil and water conservation is practised on the usually outward sloping, rainfed arable areas;
- i. population increase is likely to continue at much the present level until the end of the century: by then the 1981 population of 440 000 may well reach, without migration, 620 000;
- j. opportunities for outmigration to the traditional destinations - India and the *terai* (Gangetic plains of southern Nepal) - are likely to be substantially reduced with a consequent greater increase in the resident population; and
- k. in spite of the recent and proposed road construction, access to most parts remains limited to foot trails.

Nevertheless, the technical means of improving the management and productivity of arable, forest and grazing areas are known. Their adoption and the achievement of sustainable environmental management basically requires a more effective and sensitive support for the households and the communities of the Area. The Study therefore considers, within the context of the recent Decentralisation Act, appropriate roles and tools for local councils, Government agencies and others in order to achieve effective environmental management through:

- a. the preparation and maintenance of appropriate resource data bases (Geographic Information Systems);
- b. coordinated development planning - perspective and annual;

- c. identification and support to Users Groups linked to a resolution of the question of rights over forest/scrub/grassland areas;
- d. recognition and encouragement of the role of women;
- e. coordinated and also sectoral conservation activities, including the establishment of a National Park
- f. the setting up of a Koshi Zonal organisation;

In the circumstances of the Arun river basin, it is felt that a Zonal organisation would be more appropriate than a Watershed Authority. Such an organisation would oversee:

- (i) environmental impact and socioeconomic studies
- (ii) support to Districts in planning, implementing and evaluating development programmes
- (iii) the development of alternative sources of income, e.g. rural industries and integrated tourism, which either do not depend on the exploitation of natural resources or assist in their conservation and urbanisation
- (iv) area infra-structural development planning
- (v) marketing research on behalf of the hill farmers

In view of the present situation in the Arun River Basin, particularly with the imminent implementation of the Arun-3 hydropower project, it is recommended that this interim study should be followed up by a comprehensive and detailed enquiry to identify the means of ensuring effective environmental management of the area.

Acknowledgements

In 1978, when His Majesty's Government of Nepal, assisted by the Overseas Development Administration of the United Kingdom, initiated the Koshi Hill Area Rural Development Programme - which covered the three Districts of the Arun River Basin together with Terhathum District - little had been recorded about the area. Ten years later, there is a rich store - both formal and informal: on this I have been able to draw. I have been particularly thankful for that derived from the people and professional staff working in the Koshi hills. I am much indebted to Mr. S.P. Acharya, Coordinator, KHARDEP 1982-86 and now Joint Secretary of the Ministry of Panchayat and Local Development: I owe a great deal also to past and present staff of the Koshi Hill Development Programme, including those at Pakhribas Agricultural Centre.

Several studies commissioned by ICIMOD dealt with specific aspects of the Arun River Basin and they were thus singularly helpful: these were on geology and geomorphology by Dr. D.R. Kansakar (Department of Mines and Geology, HMG), the use of remote sensing by Mr. K.B. Malla (Director, National Remote Sensing Department), population dynamics by Dr. Pitambar

Sharma (Tribhuvan University) and development ecology by Dr. Tirtha Bahadur Shrestha (Royal Nepal Academy). In addition, I have gained further advantage from Dr. Shrestha's unique knowledge and sympathetic understanding of the people and ecology of the Arun Basin from many discussions.

ICIMOD has offered an excellent ambience for writing this Study, particularly in affording contact with staff members of wide experience and many disciplines. It is almost invidious to identify individuals but I wish to record my appreciation of the kindly support I have received from the successive heads of the Mountain Environmental Management Division, Professor Zhang Rongsu and Professor Li Tianchi, and of the benefits I have gained from continual contacts with Professor Suresh Chalise, Mr. Saroj Basnyet and Dr. Jayanta Bandopadhyay of that Division. I would also wish to thank Mr. J.M. Henley of Scott Wilson Kirkpatrick and Dr. J.L. Karmacharya of the Nepal Electricity Authority.

I am deeply grateful to Dr. Colin Rosser, Director of ICIMOD, for giving me the opportunity to write this Study and for his encouragement during its preparation.

John R. Dunsmore

Part I. The Arun River Basin

THE STUDY AREA

The Arun River Basin Study Area covers three mountain districts of the Koshi hills of eastern Nepal - Bhojpur, Dhankuta and Sankhuwasabha - within which lies the southernmost part of the basin of the Arun. The area lies between $26^{\circ} 50'$ and $27^{\circ} 50'$ North and includes four physiographic divisions - High Himalaya, High Mountain, Middle Mountain and Siwalik. In considering environmental management, the Study Area has been divided into two zones.

The Northern Zone, defined as the part lying north of $27^{\circ} 33'$ North, includes a substantial area of the High Himalaya. In general, the Zone lies above 2 500 metres, is very fragile with high relief, over 73% having slopes in excess of 40° . The climate varies from moist temperate to alpine to arctic. It is lightly populated.

The Southern Zone, predominantly comprises High and Middle Mountains and is, by contrast, heavily populated. The agro-ecological conditions vary greatly with altitude and aspect. The climate ranges from hot, dry subtropical to warm, moist temperate.

HYDROLOGY, CLIMATE, GEOLOGY AND LAND CAPABILITY

The Arun River

The Arun river originates from the Yebokanjial Glacier on the north slope of Mount Xixabanga, 8 012 m, in Tibet (Xizang). The total drainage area within Tibet, lying between latitudes $27^{\circ} 49'$ and $29^{\circ} 05'$ North and longitudes $85^{\circ} 38'$ and $88^{\circ} 57'$ East, has been estimated to be 25 307 km² (Anon 1987). From Tibet, the river flows south through the Himalayan range into the Koshi hills of Nepal. The area of the Basin within Nepal has been calculated to be 5 028 km² or 16.6% of the total area of the Basin (TEXT MAP 3).

The river predates the uplifting of the Himalayas

and its down-cutting has kept pace with this uplifting, so that at least an 8 000 metre thick rock sequence has been eroded by the river in its passage from the Tibetan Marginal Range through the Great Himalaya ranges (Hagen 1969) : the gorge thus cut is deep and narrow and the gradient of the river bed is steep (1:50). As it passes through the High Mountain physiographic division in Sankhuwasabha, Nepal, the gradient becomes more gentle, 1:360, and continues thus until it reaches the Siwaliks, shortly before the confluence with the Tamur and Sun Koshi, where the three rivers form the Sapta Koshi, one of the four major rivers of Nepal.

The total length of the Arun is 531 km, of which 155 km are in Nepal. Only limited river discharge measurements are available but a high, steady discharge is known to occur throughout the year. This is a result of snowmelt and slow drainage from Tibet in the winter and spring and the high (3-5 m) rainfall in the area between Tumlingtar and Hatiya from late June to late September: the latter supplies the greater proportion of the annual run-off (JICA 1987; Kattelmann 1988). The annual discharge of water from the Arun into the Sapta Koshi is estimated to be 18 300 million cubic metres.

Ives (1986) identified, by examination of Spacelab metric camera imagery, at least 50 ice-dammed or moraine-dammed lakes - mostly in Tibet (Xizang). He warned of the potential hazards of glacial lake outburst floods (GLOF) or *jokulhlaup* from these lakes. Subsequently, a Sino-Nepalese team undertook further investigations using large-scale topographical maps and aerial photographs. On this basis, 229 glacier lakes were identified with a total area of 46.746 km² and water reserves of 1.2309 km³. It was pointed out that "glacier lakes play an important part in adjusting the run-off circulation, are thus significant in reducing flood disasters and serve as natural water regulators... if properly managed, they may become a source of regulated water for electric power generation, irrigation water supply etc" (Anon 1987). While the potentially devastating damage that can be caused by outburst

floods was appreciated, it was noted that most of the glacier lakes in the Arun (Pum Qu) drainage basin seem stable. Furthermore, of the very small proportion prone to outburst, some will not cause unacceptable damage. It also seems possible that such outbursts can be predicted and prevented.

Within Nepal, the area of valley bottom of the Arun river and its main tributaries (TEXT MAP 2) is very limited and much of the lower slopes of the middle hills are steep with shallow soils (see Land Capability). There is thus little habitation or cultivation in the areas near to the rivers. As a result, there is very limited existing or potential use of gravity-fed water supply for drinking water or irrigation schemes. Two town hydro-electric schemes - Dhankuta and Khandbari - have been established.

For the present population of the Study Area, the Arun river and its tributaries have little economic significance: indeed their rapidly rising spate flows during the monsoon season are a serious impediment and hazard to travel.

The hydropower potential of the Arun valley within Nepal has been estimated to be in the region of 1 185 MW and plans for the development of part of this are well-advanced (see Arun-3 hydro-electric scheme)

Shrestha (1988) has noted that the fish resources of the Arun have not yet been studied, although Rajbansi (1982), on the basis of a literature review, was able to record 84 species, of which 14 were of economic interest. Several species of game fish, including Mahseer, occur and are known to be migratory and susceptible to changes in water purity.

Small water-mills (*ghatta*) are common in other parts of Nepal but few are used in the Arun Basin. One is used for milling cereals in Chirkuwa and another is to be installed for processing *allo* cloth and grinding grain in Sisuwatar. Shrestha records one in Syaksila used for turning wooden pots and another in Thudam used to produce juniper paste. Many of the small streams that occur near homesteads have a seasonal or widely fluctuating flow; nevertheless there is a potential use for these mills, particularly for reducing the workload of women in grain processing.

Climate:

Great variations in altitude and aspect within the Arun Basin result in a range of climates. The definition and delimitation of these is difficult because of the limited number of recording stations and substantial differences over short distances.

Goldsmith (1981) divided the Koshi hill area, that

TABLE 1. ARUN RIVER BASIN STUDY: CLIMATIC TYPES

Climatic Type	Landscape	Mean minimum and maximum temperature °C				Annual Rainfall mm	Altitude (metres)
		Summer		Winter			
Hot, dry subtropical	Valley bottoms	25	32	10	24	1 000	300-500
Warm, dry subtropical	Valley bottoms						
	Southern middle hills	22	30	8	22	1 000	500-1 400
Warm, moist temperate	Middle hills	18	27	6	19	1 000-2 500	800-1 700
Cool, moist temperate	Middle hills	15	22	2*	12	1 000-2 500	1 700-2 800
Cold, moist temperate	High ridges above middle hills	10	17	5**	6	1 000-2 500	2 800-4 000
	Alpine	Lower ridges of High Himalaya	***	-	***	NA	4 000-5 000
Arctic	High Himalaya					(6 months winter snow)	
						NA	> 5 000
						(Permanent snow)	

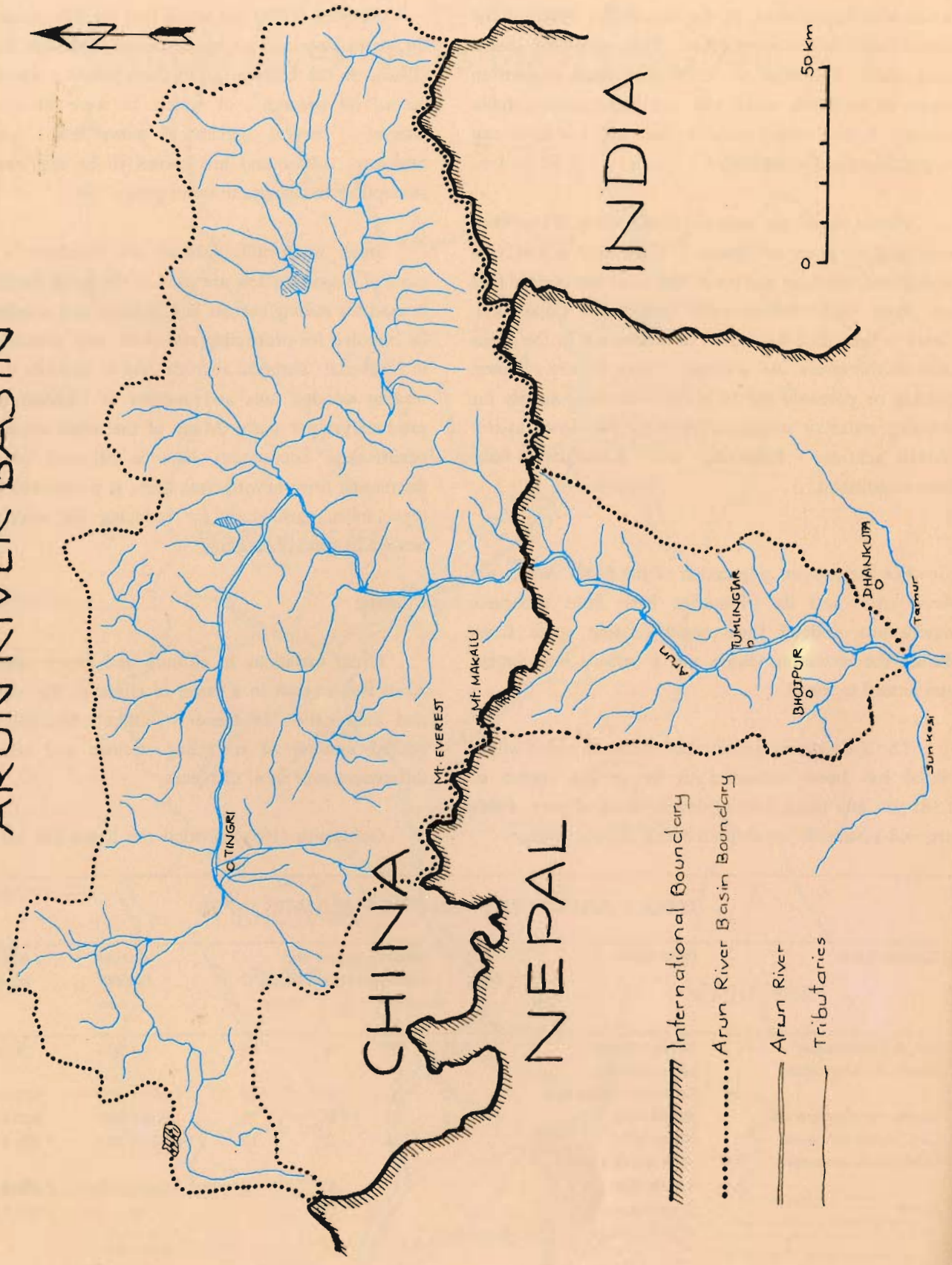
* Freezing possible on some nights

** Freezing possible every night

*** Freezing possible on every night of the year. Very short, cool summers: very cold winters

NA Not Available

TEXT MAP 3 ARUN RIVER BASIN



is, the Study Area together with the district of Terhathum, into seven climatic types on the basis of temperature and rainfall. The main characteristics of these climatic types are summarised in TABLE 1.

The climate is monsoonal, some 70% of the annual precipitation being received between June and September. Nevertheless, there may be rainfall in any month of the year and Shrestha (1988) has pointed out that the Arun Basin lies in the eastern Himalayan region, where the monsoon is more extended than elsewhere in the Kingdom (FIGURE 1). The premonsoon rainfall, April to May, is essential for agriculture (maize, millet, potato) and is valuable for encouraging a vegetative cover on other land, before the onset of the heavy precipitations of the monsoon. Some areas are particularly liable to hailstorms, which can seriously damage crops.

Geology

Kansakar (1988) has reviewed the present state of knowledge of the geology and geomorphology of the Arun River Basin and the following paragraphs are drawn from that review.

On the basis of lithology, grade of metamorphism and tectonic studies, three main lithotectonic groups were identified by Hagen (1979).

They are:

1. the Nuwakot complex.
2. the Kathmandu complex.
3. the Khumbu complex

These groups can be further divided into numerous units by tectonic breaks, which have caused the formation of tectonic scales or nappes - the rock masses which moved, as a block, a considerable horizontal distance to the south during the Himalayan mountain building processes in the early Miocene period. Two Nuwakot nappes, at least two Kathmandu nappes and one or more Khumbu nappes can be identified.

The Nuwakot nappes are the lowermost tectonic units, consisting of the least metamorphosed and the youngest sedimentary rocks in the area. They are exposed in a tectonic window in the centre of the Basin between Dingla and Diyale (north of Dhankuta). The

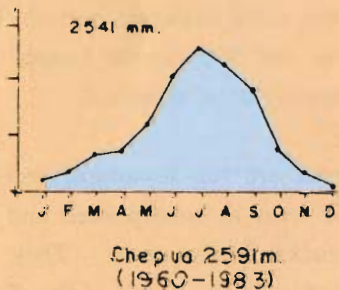
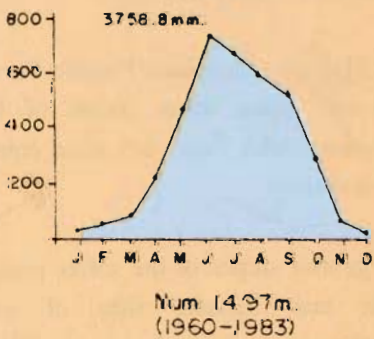
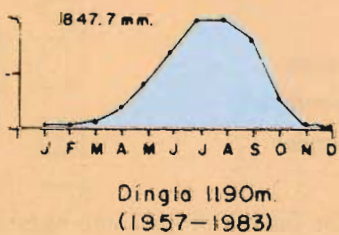
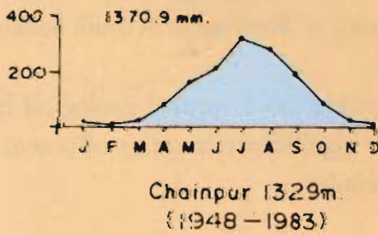
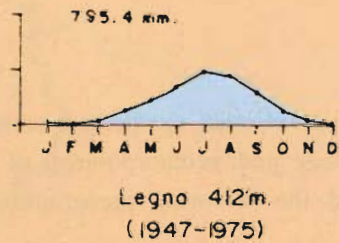
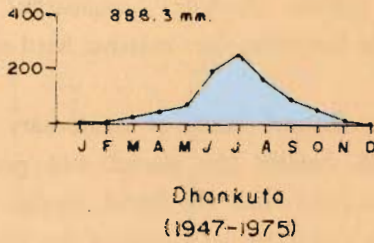
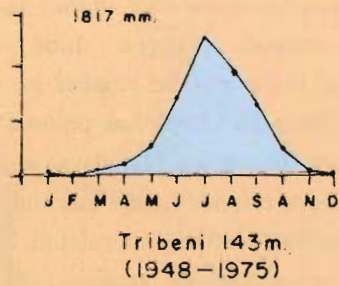
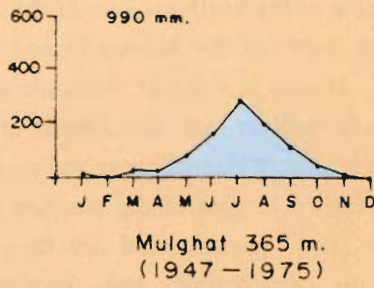
rocks of these nappes include phyllites, argillaceous quartzite and limestone, interbedded with each other. They weather and erode easily. The Nuwakot nappes are surrounded by the next higher group, the Kathmandu complex. This is exposed in a tectonic half-window in the northern part of the Arun valley and in the hill slopes of the Mayam Danda in the west and the Milke Danda in the east. Tectonic scales within the Kathmandu nappes are developed in the Barabise-Chainpur region, Ridax-Chipuwa region and in the lower Barun. The rock types of the complex include schists, quartzite and gneisses and are thus relatively more resistant to weathering and erosion. They also contain deposits of semi-precious stones including aquamarine, beryl, garnet, and tourmaline. The highest tectonic unit, the Khumbu complex, is exposed in the eastern and western flanks of the Arun Basin to the east of Ridax and the west of Thulo Pokhari. Its rock types - schists, quartzite, migmatites, gneisses and crystalline limestone - are massive, hard and resistant.

Two distinct kinds of quaternary deposits can be identified, namely the glacial and periglacial in the Northern Zone and the fluvial terrace deposits in the Southern Zone. Because most of the Northern Zone has been affected by past glaciation, a variety of glacial and periglacial landforms can be observed, much of it steeply sloping. Deposits of recent origin are very limited and are related to alluvial deposits and river terrace remnants in the major river valleys - the largest being at Tumlingtar in south Sankhuwasabha.

Kansakar has identified geological characteristics of particular significance in terms of potential slope failure. These include:

1. the alternating phyllite and quartzite sequence of the Nuwakot nappes 1 and 2 are susceptible to earth slump and earth flow;
2. the Makuwa Graphitic Phyllite Formations and the various mica schist bands of the Kathmandu complex, with their rich mica content, may cause earth slump;
3. the gentler slopes of the softer phyllite or schistose beds may become sites of accumulation of weathering products from overlying, harder rocks and, in consequence, become less stable;

FIG. I. MONTHLY RAINFALL (mm) AT REPRESENTATIVE STATIONS
(Altitude in metres)



4. the quaternary deposits are often subject to erosion by streams resulting, for example, in badland gullies if conservation measures are not taken;
5. the competent beds of quartzite, carbonate, gneiss, migmatite and granite are susceptible to rockfall. This is particularly common in the Northern Zone as a result of alternate freezing and thawing. Nevertheless, many steep slopes of competent rocks are more stable than gentler slopes of weak material;
6. observation suggests that many landslides have taken place on concave slopes due to the accumulation of surface or soil water;
7. the foot and toe of old landslide deposits are particularly sensitive and excavation may reactivate sliding;
8. alternate layers of incompetent and competent rock types causes stress in the latter and may result in rock fall;
9. landslide susceptibility may be related to the thickness of rock beds. A thick bed of hard rock may form steep scarps, where rock fall is a hazard. In contrast, thick beds of incompetent rocks may be subject to earth slump or flow.

The Himalayan Range is seismically still active, particularly the zones of the Main Boundary Thrust in the south and the main Central Thrust in the north. The latter lies close to the proposed site of the Arun-3 hydro-electric project (q.v.). The Nepal Electricity Authority, in a prefeasibility study of the project in 1985, estimated the magnitude of earthquakes at the 1% exceedance probability for Central and Eastern Nepal as 7.04 (Richter scale) with a mean return period of 96 years. An earthquake with a magnitude of 6.7 on the Richter scale struck Eastern Nepal on 21st August 1988. Its epicentre was Udaypur. Within the three Arun Basin Districts, 119 people were killed and 1 131 injured. Dhankuta District was particularly seriously affected : 3 308 houses and 91 other buildings were destroyed. Kansakar (1988) has noted that this earthquake demonstrated that structures built on quaternary alluvial fan deposits, terraced alluvial deposits or man-made fill structures are generally more susceptible to failure than others.

Land Capability

Goldsmith (1981) undertook a broad reconnaissance level study of the land and soil resources of the area of the four Koshi hill districts lying south of Num, 27° 33' North, that is the Southern Zone of the Arun River Basin together with Terhathum District. It was found in the field that the reconnaissance soil survey could not consistently delineate the highly variable soils of differing colours, depth, texture or stoniness. Furthermore, soil quality and fertility were not the primary determinants of land use - the three important factors were climate, slope angle and soil depth. It was these, therefore, that were used for the classification (and subsequently for land evaluation, using the FAO framework, for six major land utilization types.) It is not possible to disaggregate the figures to District level but the results give a guide to probable land capability in the Study Area.

TABLE 2 records the estimates of areas by slope and soil depth categories for the various climate/altitudinal zones. Points that stand out from these figures include:

- a) the area of land with few limitations (slopes less than 15°, soils deeper than 20 cm) is only some 15% of the total. Land with moderate limitations (slopes 15-30°, soils deeper than 20 cm) cover a further 41%
- b) The area of gently sloping land (0-4°) in the subtropical zone is negligible (0.7%). It is found in the valley bottoms - areas of low rainfall. They are well-suited to irrigated arable crop production
- c) the lower slopes - 500-1 400m - of the southern middle hills have a low rainfall and are predominantly steep with shallow soils. Their use is thus largely confined to the production of fodder and fuelwood
- d) Between 1 700 and 2 800 m, 64% of the area carries shallow soil (less than 20 cm). Only 11% of the area has soils deeper than 20 cm on slopes less than 15° and are thus relatively suitable for terracing for arable crop production. Arable crop production at this altitude is further limited by the climate - cool, moist temperate. Few technological improvements for arable crop production are known for these

TABLE 2. KOSHI HILL DISTRICTS. AREAS OF SOIL DEPTH/SLOPE CATEGORIES (HECTARES)

CLIMATE (ALTITUDE,m)	LANDSCAPE	Soil Depth > 20cm		Soil Depth > 20 cm		Slope > 30°		TOTAL	
		Slope < 15°	Slope 15-30°	Slope > 30°	Soil > 20cm	Soil < 20cm	ha	%	
1. Hot, dry subtropical (300-500)	Valley bottoms	1 930*	0	60	0	0	1 990	0.4	
2. Warm, dry subtropical (500-1 400)	Valley bottoms	1 260*	0	0	0	0	1 260	0.3	
	Southern middle hills								
	- lower slopes	0	0	0	0	30 870	30 870	6.8	
	- mid&upper slopes	19 510	59 350	23 010	2 030	0	103 900	22.8	
3. Warm, moist temperate (800-1 700)	Middle hills	32 480	103 990	12 160	4 340	34 970	187 940	41.3	
4. Cool, moist temperate (1 700-2 800)	Middle hills	11 650	23 060	31 500	2 640	36 500	105 350	23.2	
5. Cold,moist temperate (2 800-4 000)	High ridges above middle hills	290	60	7 340	160	13 370	21 220	4.7	
6. Alpine (4 000-5 000)	Lower ridges of High Himalaya	0	0	820	0	1270	2 090	0.5	
TOTAL		67 120	186 460	74 890	9 170	116 980	454 620	100.0	
Percentage of Total		14.8	41.0	16.5	2.0	25.7			

* Slope < 4°

(Source: Goldsmith 1987)

conditions (PAC 1988). The area is suitable for tree crops and grazing but improved environmental management will almost certainly require support to farmers in improved methods of arable crop production and a comprehensive programme for this has yet to be defined.

The overall gross density of population in the Basin in 1981 was 76/km² compared with the National average of 102. The significance of this figure in a basically agricultural area must be assessed in relation to the land and water resources of the Basin: this is considered in the section on availability of arable land.

POPULATION

Introduction

The majority of the population of the Arun Basin are farming families living dispersed over the hillsides they farm, particularly between altitudes 300 to 2 200 metres. There are only four towns, none with a population exceeding 14 000: three of them are District headquarters.

Population Distribution

The 1981 Population Census recorded the following populations in the three Districts of the Study Area

Bhojpur	192 689
Dhankuta	129 781
Sankhuwasabha	129 414
<u>TOTAL</u>	<u>451 884</u>

The six Village Panchayats which lie in the Study's Northern Zone had a population of 12 327, or 2.7 % of the total for the three Districts.

Ethnicity

The Arun river basin is part of the land that is believed to have been occupied for several millenia by the Kiranti people, who speak a number of Tibeto-Burman dialects (Bista 1980). The Arun river broadly divides the two main groups of these people - the Rais to the West ("Khumbuan") and the Limbus to the East ("Limbian"). From the early 19th century, the Government of the recently unified Nepal encouraged the migration into the area of high-caste Hindus (Brahmin and Chhetri). They particularly occupied land at lower altitudes and introduced irrigated rice cultivation (Howarth and Pant, 1987). Subsequently, the social and cultural order of the area has also been influenced by the Hindu caste system (Howard 1985).

Occupational castes - blacksmith, shoemaker, tailor - also settled throughout most of the area. Newars from the Kathmandu valley, now the main shopkeeping and commercial group, migrated principally to the District towns, Chainpur and Taksar. There are smaller numbers

ARUN BASIN STUDY AREA

TEXT MAP 4

PHYSIOGRAPHIC REPRESENTATION
OF THE ARUN RIVER BASIN, NEPAL

TIBET

MECHI ZONE

SAGARMATHA
ZONE

SANKHUWASABHA
DISTRICT

BHOJPUR
DISTRICT

TERHATHUM
DISTRICT

DHANKUTA
DISTRICT

- o—o—o—o— international border
- == motorable road
- - - - proposed road
- - - - leading to proposed dam site
- - - - main trails
- district capital
- village
- river

of other Tibeto-Burman speaking communities including Tamangs, Magars and Gurungs and particularly in the north, people of Tibetan origin: the Gurungs are prominent as shepherds in Sankhuwasabha.

The Nepalese Population Census does not record ethnicity and the recorded mother tongue is unsatisfactory as a proximate indicator. The current breakdown of the population for the Koshi hill districts has been estimated as follows (Dunsmore 1987) and is probably broadly correct for the Arun basin.

	%
Rai, Limbu, Gurung, Magar	53
Brahmin and Chhetri	27
Occupational castes	7
Tamang, Sherpa, Tibetan	7
Newar	5
Others	1

Population Dynamics

A review of the population dynamics in the Arun watershed was undertaken by Sharma (1988) as a contribution to the ICIMOD study. Some of the major findings of this review are summarised in the following paragraphs.

Population Growth, 1952 - 1981

It is difficult to quantify population growth in the Arun Basin over the period since the 1952 Census, one problem being the boundary changes that have been made in the intervening period. Nevertheless, Sharma was able to calculate the population of the areas now comprising the three Districts from the 1952, 1971 and 1981 Censuses: the results are summarised in TABLE 3

The annual population increase in the three Districts between 1952 and 1981 was 1.22 %: this compares with the National figure of 2.16, and 1.65 %/year for the hill/ mountain region overall. The figure for the 1971/1981 inter-censal period was 1.04 %, compared with the National increase of 2.66% and 1.62% for the hill/mountain region.

Age and Sex Structure

The age distribution for the Study Area, below, was broadly similar to that of other hill/mountain populations: so also was the sex structure with a predominance of males, the sex ratios being 102.6 in Sankhuwasabha, 102.0 in Bhojpur and 104.1 in Dhankuta. The ratio was lower among Limbus and Gurungs in particular and, less markedly, among the other Tibeto-Burman groups.

The median age was very close to the national one of 19.9 years. The dependency ratio was 87, that is, 87 dependents per 100 working population.

Age range	%
< 15	39.9
15 - 24	20.2
25 - 59	33.3
60 +	6.6

Household Size

The 1981 Census recorded a total of 84 279 households in the three Districts, which would give an average household size of 5.36. The District averages ranged from 4.8 in Sankhuwasabha to 5.8 for Dhankuta. These figures compare with an average household size of 6.5 recorded by Conlin and Falk (1979) in their reconnaissance study of the socio-economics of the Koshi

TABLE 3 : DISTRICT POPULATIONS 1952, 1971, and 1981

DISTRICT	AREA KM ²	1952		1971			1981		
		A	C	A	B	C	A	B	C
Bhojpur	1 502.05	140 000	93	177 887	1.27	118	192 689	0.80	128
Dhankuta	876.72	76 000	87	110 428	1.98	126	29 781	1.63	148
Sankhuwasabha	3 574.00	102 000	28	118 964	0.81	33	12 414	0.84	36
ARUN BASIN	5 952.77	318 000	53	407 279	1.31	68	451 884	1.04	76

A : Population

B : Percentage increase per year

C : Population per square kilometre

hill districts (which included Terhathum) and 7.7 in the 234 households in eight locations selected to assess the impact of the Koshi Hill Area Rural Development Programme, KHARDEP (Nabarro *et al* 1987). Conlin and Falk noted variations in household size with ethnicity: Nabarro *et al* found that wealthier households tended to be larger.

Total Fertility Rate

The Total Fertility Rate appears to have changed very little between 1971 and 1981. Completed fertility remains high, over 6, particularly among Rai women. While family planning has gained some acceptance in Dhankuta Town Panchayat, it is little practised among the rural population. There seems little likelihood of a decline in the Fertility Rate in the next five years or so, particularly while child mortality, perhaps as high as 40 - 50 % by the age of 5, remains so high.

Mobility and Population

There has long been a tradition of migration, both seasonal and long-term, among the people of the Arun Basin. Sharma has estimated that, at the time of the 1981 Census, the numbers of net life-time migrants from Bhojpur, Dhankuta and Sankhuwasabha were 35 858, 24 152 and 81 095 respectively - net migration rates of 19.3, 20.1 and 65.3 per 100 population, " an extremely high rate of migration ". The main destination of the migrants was the eastern *terai*. Emigration to India was also common. 17 000, including 9 000 from Sankhuwasabha, were recorded by the Census as outside Nepal; a high proportion of these would have been in India

Population Projections

Population projections for the Arun Basin are of questionable value in the absence of enumerated age/sex breakdowns and survival rates: also, it is not feasible to estimate the future rates of migration because of the probable reduction in opportunities available in traditional destinations. Sharma considered three scenarios with the results shown below. The figures do not assume any migration: the base 1981 population was 451 884.

Commenting on these projections, Sharma compares the position in the Arun Basin with that in other similar areas of Nepal and notes that:

Scenario	Assumed Average		Projected Population	
	Growth Rate/Year		1991	2001
	1981-91	1991-2001		
1	1.50	1.50	524 411	608 597
2	1.62	1.50	530 647	615 782
3	2.00	1.50	550 801	639 235

- the population levels - gross and relative to the area of arable land - are lower than elsewhere;
- the apparent rate of population growth is less.

COMMUNICATIONS

Access to most of the Arun Basin is only possible on foot. There is very limited use of pack animals: most goods therefore are carried by porters. The two major traditional foottrails linking the Basin to the southern plains, *terai*, ran respectively a) through Chatra and Tribeni to Bhojpur (and thence to Diktel in Sagarmatha Zone to the west) and b) via Dharan to Mulghat and Dhankuta and thence west to Sankhuwasabha and east to Terhathum and Taplejung. The trail to the east is part of an old trade route to Tibet (Füerer-Haimendorf 1975). These main trails and others of significance are shown on TEXT MAP 1. Their condition varies considerably and, particularly in the monsoon season, travel can be difficult and, at times, hazardous.

In 1983, vehicular access into the Basin was obtained with the completion of the Dharan-Dhankuta road (50 km). Subsequently, this road was extended to Hile and Basantapur (Terhathum district) - a further 35 km. A continuation of this road has been designed as part of the proposed Arun-3 hydro-electric scheme, (q.v.)

Two small airfields, served by scheduled flights, are located respectively at Tumlingtar, near Khandbari, Sankhuwasabha and near the District head-quarters of Bhojpur.

Trials have been undertaken on the use of jet-propelled barges between Chatra and Tumlingtar. Following the clearance of obstructions in the river,



1.

PLATES 1 - 6: FARMING LANDSCAPES

1. The Arun river south of Hedangna looking towards Num (top left) showing area of mixed hardwood forest
2. Besinda, Sisuwa khola panchayat, Sankhuwasabha. Above 1 700 metres, cool, temperate climate with short growing season, uncertain yields
3. Boya panchayat, Bhojpur. Warm, temperate climate, arable cropping intensities can be high, particularly if irrigation is available
4. Above 3 000 metres, transhumant stock husbandry is practised with yaks and their crosses, sheep and goats. Sheep grazing Milke Danda
5. In the middle hills, livestock are key sources of food, income, draught power and manure
6. Terraced crop production - wheat, mustard and buckwheat



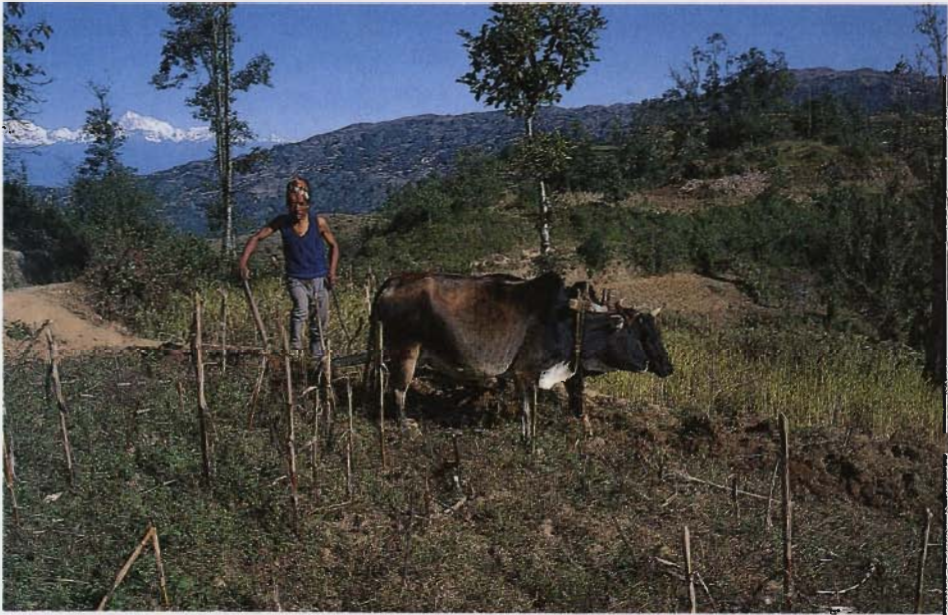
2.



3.



4.



5.



6.

specially adapted barges are expected to be able to undertake daily round trips carrying two tons of freight. They could be used to supply material for the Arun-3 access road construction.

VEGETATION

Introduction

The vegetation types of the Arun Basin within Nepal have been classified and described by a number of authors: among the most recent are Shrestha (1988), Stewart (1987) and Abell (1981). Shrestha emphasised that vegetation types change with altitude, latitude, slope angle, slope aspect, soils and rainfall. There is a particular diversity between 1 000 and 3 000 metres altitude: this is also the principal area of human occupation and cultivation. Over 1 600 plants, including 60 currently used as fodder trees, have been recorded between 1 000 and 2 000 metres. They include rare and endangered species such as *Talauma hodgsonii*, *Cythea spinulosa*, *Podocarpus nerifolius*, *Quercus fenestratus* and *Gnetum montanum*

Forest and Scrub

Stewart (1987) defined eight forest types and his and Shrestha's (1988) findings on forest and scrub may be considered within this framework. Each type "contains an enormous variation in species composition, age and size range, site type and utility." (Stewart).

The eight types are:

1. Dry valley forest and deciduous hill forest
 2. Lower slope mixed hardwoods
 3. Upper slope mixed hardwoods
 4. Chir pine
 5. High altitude coniferous forest
 6. Rhododendron
 7. Temperate deciduous forest
 8. Moist Alpine Scrub
1. Dry valley forest and deciduous hill forest (altitude 300 - 1 000 metres) is a combination of several sub-types including *Dalbergia sissoo* / *Acacia catechu* associated with river alluvium, *Adina cordifolia*, *Lagerstroemia parviflora* and *Sapium*

TABLE 4. ARUN RIVER BASIN STUDY: AREAS OF FOREST TYPES BY DISTRICT - SOUTHERN ZONE (1978) in Hectares

FOREST TYPE	DISTRICT			
	Bhojpur	Dhankuta	Sankhuwasabha	TOTAL
Dry valley/deciduous hill forest	22 270	19 480	16 660	58 410
Lower slope mixed hardwood forest	18 620	7 550	15 090	41 260
Upper slope mixed hardwood forest	16 110	1 400	13 370	30 880
Intimate mixture of dry valley/deciduous hill and Chir pine forest	2 330	1 820	10	4 160
Chir pine forest	3 770	3 700	210	7 680
High altitude coniferous forest	1 080	0	80	1 160
Rhododendron forest	580	0	1 090	1 670
Temperate deciduous forest	3 410	0	7 250	10 660
Moist alpine scrub	250	0	270	520
TOTAL	68 420	33 950	54 030	156 400

Source: Stewart (1987)

insigne on sandy soils, *Shorea robusta* in southern Bhojpur and the Tumlingtar-Khandbari area. In drier areas, on the lower hill slopes, *S. robusta* often forms an association with chir pine (*Pinus roxburghii*).

2. Lower slope mixed hardwoods occur in a zone of intense cultivation and population pressure. Little of the climax vegetation, therefore, still exists. Where it does, *Castanopsis* (chestnut) species predominate: *C. indica* below 1 500 metres, *C. tribuloides* between 1 500 and 2 000 metres. *Castanopsis* may also be associated with *Schima wallichii*. *Schima* may be found on all aspects of slope not only the northerly ones as in Central Nepal. Where the forest has been exploited by villagers, a number of shrubs and trees may be found including *Engelhardtia spicata*, *Callicarpa arborea*, *Rhus javanicus*, *Osbeckia stellata* and *Mallotus philippinensis*. The forest floor may have a dense undergrowth of *Nephrolepis* fern in drier areas and *Eupatorium* in ravines and gullies. *Schima wallichii* can regenerate naturally very well.
3. Upper slope mixed hardwoods are found above the main zone of cultivation and have a diverse mixture of species and associations, dominated by *Quercus*, *Lithocarpus* and *Rhododendron* species. The often dense and impenetrable under-storey consists of *Daphne* spp., *Mahonia acanthifolia*, *Ribes* spp., *Berberis* spp., *Viburnum* spp. and *Rosa* spp.. Shrestha (1988) considers this Type and Type 7, Temperate Deciduous Forest, together as temperate forest and places it at 2 000 to 3 000 metres. He records a great floristic diversity - 1 400 species - and defines two categories. The lower temperate category is characterised by an oak-laurel forest with a number of Magnoliaceae plants. The first canopy of trees, *Quercus lamellosa*, grows to a height of 35 - 40 metres, with a second storey of lauraceous trees and magnolias at 12 - 15 metres. Bamboos are found on disturbed, drier, steep (>40°) slopes: on gentler slopes, big-leaved shrubs and trees such as *Mallotus nepalensis*, *Ehretia macrophylla* and *Leucocephalum canum* form the secondary vegetation. Partial disturbance of these forests may bring in such economic plants as *Lycopodium clavatum* (medicinal), *Daphne* spp (paper) and *Girardinia diversifolia* (fibre).

The upper temperate category - above 2 500 metres - is further enriched with a number of deciduous species, particularly *Acer campbellii* (maple) and *Magnolia campbellii* also *Sorbus cuspidata* (Himalayan bean), *Tetracentron sinense*, *Prunus nepalensis*, *Pentapanax* spp and the birchs *Betula cylindrostachya* and *B. utilis*. The secondary layer may include *Osmanthus suavis*, *Ilex dipyrena*, *Corylus ferox* and *Symplocos* spp and laurels. Bamboos will colonise areas where the natural vegetation has been disturbed.

4. Chir pine, *Pinus roxburghii*, is found up to about 1 500 metres and is particularly common on hot, dry, southern slopes, where rainfall is less than 1 000 mm per year.
5. High altitude coniferous forest occurs between 2 800 and 3 400 metres and is dominated by *Tsuga dumosa*, *Abies spectabilis* (silver fir) and *Pinus wallichiana*. Stewart (1987) comments that this Type is of little importance south of Num.
6. Rhododendron forest is found between 2 000 and 4 500 metres, as part of the shrub layer within *Quercus* and *Castanopsis* forest, in association with all high altitude forest and as dense stands. Bannerji (1965) recorded 15 species. Pure stands of *R. arboreum*, the National Flower of Nepal, are found on drier, south-facing slopes.
7. Temperate deciduous forest was considered above (Type 3)
8. Moist Alpine Scrub formations are found at high altitude (4 000 - 5 000 metres) on shallow, rocky soils. Stainton (1972) noted that this Type was dominated by dwarf *Rhododendron* spp, *Juniperus recurva*, *Salix* spp and *Lonicera* spp.

Shrestha (1988) comments on the floristic richness of the Alpine Zone, particularly as regards flowers and medicinal plants: 450 species of flowering plants have been recorded.

The area of each forest type in the southern zone is presented in TABLE 4. The data are based on interpretation of aerial photography flown in 1978.

TABLE 5. THE ARUN RIVER BASIN: RECOMMENDED FODDER TREE SPECIES

Species	Altitudinal range m	Fodder Collection Season	Propagation means	Remarks
<i>Quercus glauca</i>	400 - 3 000	Spring	Seeds	on northern slopes
<i>Q.lamellosa</i>	400 - 2 600	Autumn/winter	Seeds	on southern slopes
<i>Alnus nepalensis</i>	400 - 2 600	Autumn/winter	Seeds	in ravines
<i>Ficus auriculata</i> = <i>roxburghii</i>	250 - 1 800	Winter/Summer	Seed/Cutting	farm land
<i>Sauraja nepalensis</i>	700 - 2 100	Winter	Seed/Cutting	farm land
<i>Bauhinia purpurea</i>	200 - 1 000	Winter	Seed/Cutting	farm land
<i>B.variegata</i>	150 - 2 200	Winter	Seed/Cutting	farm land
<i>B.malabaricum</i>	200 - 1 000	Winter	Seed/Cutting	farm land
<i>Quercus semecarpifolia</i>	1 700 - 3 800	Winter/Spring	Seeds	Dry rocky slopes
<i>Acer campbellii</i>	2 100 - 3 600	Summer	Seeds	Deciduous, plant on northern slopes

Source: Shrestha (1988)

Fodder Trees

Shrestha (1988) lists 77 native trees and shrubs in the Arun basin which are used as a source of fodder. They are found at altitudes from 200 - 4 000 metres, both in public forest and planted on private land. So far, 25 of the species have been classified as first grade, indicating that their dry matter content exceeds 30% and their ash content is less than 10%. A number of fodder species will grow well over a large altitudinal range: Shrestha lists 10 such species for the various conditions of the Arun basin (TABLE 5).

Because of the serious shortage of fodder during the dry season, over-logging is almost universal: this often leads to mast-like trees which permit the invasion of *Eupatorium*; this, in turn, results in the suppression of fodder seedling development and competition for nutrients. Shrestha notes the ironical result of such degradation in the village of Gogan (1 900 m) where no Gaugane trees (*Sauroja nepalensis*) remain.

Medicinal Plants

Burbage (1982) recorded 32 plants in the Koshi zone which are used for medicinal purposes. Shrestha

(1988) notes that the zone between 3 000 and 4 000 metres is a rich source of such plants.

The collection and sale of the products of these plants can be an important source of income to some of the poorest households in the Arun basin. Unfortunately, there is no organised collection or marketing and local processing is very limited. The national figure of 90% of the collected products going unprocessed to India probably applies to the Arun basin.

Aspects of the trade are a cause for considerable concern. National figures show a dramatic fall in export earnings from NCR 102.6 million in 1974/75 to NCR 14.04 million in 1984/85 (MFSC 1988): a major factor in this fall is the depletion of the resource base. Shrestha records that, in the Arun basin, some high altitude species, including *Picrorrhiza scrophulariiflora*, *Nardostachys jatamansi* and *Aconitum heterophyllum* have been seriously depleted and several sub-tropical species, including *Rauwolfia* sp and *Alstonia* sp, are approaching extinction. Species at particular risk are those, including the three high altitude species noted above, of which the collected item consists of the root, rhizome or other

plant storage organ, where the whole plant is destroyed at harvest.

Fibre Plants

A. "Lokta".

Shrestha (1988) records that in the oak/laurel and oak/rhododendron forests (2 100 - 2 700 metres) there is extensive collection of bark from three shrubs of the Thymeliaceae family - *Daphne bholua*, *D. papyracea* and *Edgeworthia gardeneri*. The bast fibres ("lokta") are used for paper making. As collection destroys the plant, it is important that it should not be undertaken before seeding and also that the roots are not disturbed; (regeneration takes place from both seed and root suckers - Jeanrenaud 1987)

Shrestha states that the Nepal paper of Bhojpur has a high reputation in Kathmandu but warns about the danger of over-exploitation of the plants and also the high demand for fuelwood in the preparation of the paper.

B. "Allo".

The nettle *Girardinia diversifolia* (*allo*) is found as under-growth at altitudes of 1 500 to 3 000 metres. Fibre from its inner bark has long been used for making coarse cloth, cast nets, sacks and head bands. In recent years it has been shown that the *allo* yarn can be used to produce good quality cloth, either on its own, when a linen-like cloth results, or as the warp with wool as weft when tweed-like cloth is produced (Dunsmore S, 1985). Further development of these cloths is needed but there appears to be a good market for both.

The plant seeds profusely and regenerates also from root suckers: sustainable exploitation should not therefore be difficult. The weavers - predominantly Rai women - live in remote areas where agricultural development is extremely limited. The advantages of developing the new cloths could therefore be very substantial in these and other similar areas of Nepal both economically and environmentally.

Bamboos

The various species of bamboo found in the Arun basin constitute one of the most versatile and important

sources of plant materials available to the people.

The large-statured bamboos - " bans " -, of which there are 11 species within two genera, *Bambusa* and *Dendrocalamus*, are used in building houses, sheds and bridges, for making woven mats, partitions and roofing and for carrying-pots for water. The young shoots are used as a vegetable and the leaves are fed to livestock. The preferred species for most people is *Dendrocalamus hamiltonii*, "Tama Bans", (Shrestha 1988).

The small-statured bamboos are considered to be of higher quality for woven items, such as baskets and roofing. Nine species have been identified within the genera *Drepanostachyum*, *Arundinaria* and *Thamnocalamus* (Stapleton 1987). Most are found at the higher altitudes, above 1 200 metres, the most valued, *Arundinaria maling* ("malingo") occurring above 2 300 metres. Using this species, the people of Ankhisalla, Dhankuta have been assisted to adapt traditional methods to make a range of items - fruit and bread baskets, laundry and wastepaper baskets, lampshades, bags and storage baskets - for which there appears to be a good market - local, tourist and in the hotels of Kathmandu (Dunsmore 1987). Other species are a source of edible shoots or used for making pens or smoking pipes (Shrestha 1988).

Grassland

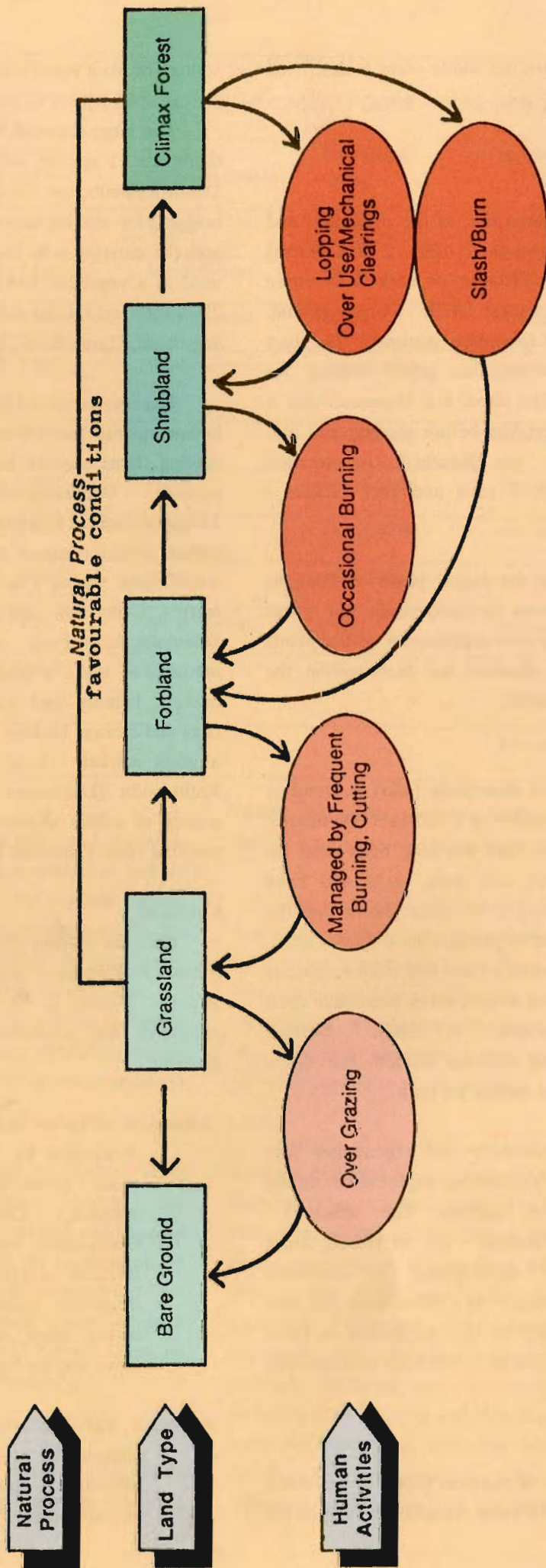
Shrestha (1988) has defined and described, as follows, four zones of grassland vegetation, delimited by altitude. [There is no sown pasture and areas of grassland are extensively, rather than rotationally, grazed.]

A-Zone, at altitudes below 1 100 metres is naturally dominated by annual plants, propagated by seed: common species include *Cynodon dactylon*, *Chrysopogon aciculatus* and *Desmodium trifolium*. Overgrazing leads to invasion by clumps of *Eupatorium odoratum*, *Anaphalis contortus* and *Artemesia* spp.; in severe cases of over-grazing the vegetative cover may be destroyed.

B-Zone, 1 100 - 2 600 metres. Grassland at this altitude, if well-managed, would include the following grazing species - *Paspalum scrobiculatum*, *Pycreus sanguinolentus*, *Cynodon*

General Pattern of Grassland Succession

FIGURE 2.



Source: Shrestha (1988)

dactylon and *Setaria pallidifusca*. Much of the grassland in this Zone though has been overgrazed, resulting in the invasion of *Eupatorium*, *Artemesia*, *Anaphalis*, and ferns. Within about a decade, such forbland degenerates, in terms of grazing, into shrubland.

C-Zone, 2 600 -3 800 metres. *Carex* spp and a number of flowering herbs are characteristically dominant in this Zone, which progresses into forbland of Compositae, including species of *Circium*, *Senecio* and *Anaphalis*.

D-Zone, lies between the natural tree-line (3 800 metres) and the snow line and "consists of vast stretches of alpine grassland with the dominance of species of *Calamogrostis*, *Carex* and *Festuca*." Over-grazing by sheep and yaks leads to the invasion of unpalatable (but colourfully flowering) plants, particularly *Primula* spp, which may cover substantial areas.

If left undisturbed, grassland will develop naturally to forbland, then shrubland and finally climax forest. TABLE 6 records the major species in each successional type for the different altitudinal Zones. Man's intervention can reverse this succession as is illustrated by FIGURE 2

Eupatorium

Two species of *Eupatorium* invade grassland. *E. adenophorum* is found particularly on ridges and slopes at 1 200 to 1 850 metres. *E. odoratum* is found at lower altitudes, commonly in the herb layer of dry valley forest and deciduous hill forest. Shrestha (1988) records that the spread of *Eupatorium* ("banmara") in Nepal started in the early 1950s and that it has an altitudinal range of 800 to 2 000 metres. Although unsuitable for grazing or browsing, it is beneficial in affording vegetative cover even on fresh landslides. It can be used also for making compost and as cattle bedding.

TABLE 6. ARUN RIVER BASIN STUDY: ALTITUDINAL ZONES OF GRASSLANDS AND THEIR SUCCESSIONAL TYPES

Altitude Zone m.	Grassland Type	Forbland Type	Shrubland Type	Climax Forest
1 100	A Cynadon sp Chrysopogon aciculatum Cyperus sp	Saccharum sp Eupatorium sp Cassia sp Ficus sp	Maesa sp Callicarpa sp Lantana sp	Shorea sp Terminalia sp
	B Paspalum scrobiculatum Setaria pallidifusca Arthraxon sp Cynadon dactylon Pycneus sp	Eupatorium sp Thelyptis sp Pteridium sp Artemesia sp Ageratum sp	Eurya sp Maesa sp Osbeckis sp Arundinaria sp Viburnum sp	Schima sp Castanopsis sp Quercus sp Lithocarpus sp
2 600	C Carex spp Poa annua Plantago minor Rumex spp	Senecio spp Circium spp Anaphalis spp Tsuga spp Abies spp	Rhododendron spp Rubus spp Sorbus spp Betula spp	Rhododendron spp Acer spp
		D Calamogrostis sp Festuca sp Agrotis sp Carex sp	Alpine herbs	Rhododendron spp Juniper spp
3 800				

Source : Shrestha (1988) after Tsuchida (1983)

Biological Diversity

Shrestha (1988) has noted that the Arun basin marks the beginning of the east Himalayan humid flora and is an area of great biological diversity. He goes on to draw attention to the range of commodities that this richness offers to the community but warns that much remains unknown about the potential to produce medicines, oils, fibres, fodders and other beneficial items. Particularly in the areas of intensive farming, there is a grave danger of species becoming extinct before their potential value has been discovered.

LAND USE

Southern Zone. The areas under different categories of land use in the Southern Zone were quantified by Stewart (1987), interpreting 1:20 000 (approximate scale) black and white aerial photography flown in November 1978. Subsequently, the interpreted detail was plotted on contoured maps (scale 1:25 000). The area of the land use types was calculated for each Village Panchayat using a dot grid overlay with a density

of 2 dots per hectare. Nine forest types and Eupatorium and grassland were identified and their areas estimated (See chapter on Vegetation-Forest and Shrub)

In addition, forest and woody vegetation were

- A. classified according to two predominant heights, above or below 5 m.: this separated woodland from shrub
- B. categorised according to canopy closure, namely greater than 75%, 75-50% and 50-20%.

Agricultural land was sub-divided into areas where cultivation exceeded 90% and those where 80-90% was cultivated. The other land use types were landslips, rock outcrops and urban areas. The District totals for the various land use types are given in TABLE 7. These are summarised by percentages in TABLE 8. The very high percentage of land under arable cultivation - in Dhankuta 46.5% of the area comprising land with over 80% cultivation - is remarkable in view of the widely accepted assumption that the maintenance of soil fertility of arable land requires an area of accessible

TABLE 7: ARUN RIVER BASIN- SOUTHERN ZONE: LAND USE TYPES (ha)

LAND USE TYPE	DISTRICT			TOTAL
	Bhojpur	Dhankuta	Sankhuwasabha	
I. ARABLE CULTIVATION				
A. > 90% cultivated	26 070	12 890	18 610	57 570
B. 80-90% cultivated	33 680	27 920	20 180	81 780
II. GRASSLAND/EUPATORIUM	19 927	11 768	17 168	48 863
III. FOREST AND WOODY VEGETATION				
A. Canopy closure > 50%				
i) Predominant height > 5m	32 947	10 887	28 413	72 247
ii) Predominant height < 5m	14 738	10 115	11 974	36 827
B. Canopy closure 20--50%				
i) Predominant height > 5m	8 260	3 702	6 437	18 399
ii) Predominant height < 5m	12 430	8 337	7 192	27 959
TOTAL WOODY VEGETATION AND FOREST WITH CANOPY CLOSURE > 20%	68 375	33 041	54 016	155 432
III. C. Canopy closure < 20% height < 5m	56	904	0	960
IV. LANDSLIDE, ROCK OUTCROP ETC.	936	1 042	2 308	4 286
V. URBAN	27	110	44	181
VI NO AIRPHOTO COVER	1 150	0	60	1 210
TOTAL	150 221	87 675	112 386	350 282

Source : Stewart (1987)

TABLE 8. ARUN RIVER BASIN - SOUTHERN ZONE: LAND USE (1978) PERCENTAGES

LAND USE TYPE	DISTRICT		
	BHOJPUR	DHANKUTA	SANKHUWASABHA
Arable (>80%)	39.8	46.5	34.5
Forest - canopy > 50%	31.7	23.9	35.9
- canopy 20-50%	13.8	13.7	12.1
Grassland/Eupatorium	13.3	13.4	15.3
Urban areas, landslides etc .	1.4	2.5	2.2

Source: Stewart (1987)

unmanaged forest three to six times that of the arable area (Mahat 1987, Wyatt-Smith 1982, Applegate and Gilmour 1987). The overall figure for forest with a canopy cover exceeding 50% is satisfactory for Bhojpur (31.7%) and southern Sankuwasa bha (35.9%) and fair for Dhankuta (23.9%) but there are considerable local variations.

Forest with a canopy closure of 20-50% may be regarded as indicative of poorly or unmanaged forest, which is being over-exploited. Similarly, the Grassland/Eupatorium areas are over-exploited and of low productivity.

Northern Zone

Data on land use in the Northern Zone is less detailed than for the Southern Zone. Shrestha (1988),

using Land Resource Mapping Project data (Kenting Earth Sciences Ltd 1987), has calculated the area of four broad categories for the nine sub-catchment areas of the Zone (TABLE 9). The first four sub-catchments listed run up to the border with Tibet. The percentage of cultivated land is low (0.7 %), the major land use being grazing (24.4%): 45.5% lies under permanent snow, rock etc. In the remaining sub-catchments, the cultivated area is slightly greater - 5.4% - and the unutilisable proportion lower - 20.9%.

LAND TENURE

Legally, the position regarding land tenure in the Arun Basin appears to be straightforward. Cadastral surveys have been undertaken by the Department of Surveys Cadastral Survey Branch in two of the Districts

TABLE 9: ARUN RIVER BASIN - NORTHERN ZONE: LAND USE TYPES

Sub-catchment	Forest/Shrub		Agriculture		Grassland		Other*		TOTAL
	ha	%	ha	%	ha	%	ha	%	
1. Barun	11 484	23.3	322	0.7	8 457	17.2	28 983	58.8	49 246
2. Sursing, Chhokang Chyaling & Hadandi	7 995	54.5	260	1.8	6 368	43.4	40	0.3	14 663
3. Bakan	2 450	22.4	-	-	4 890	44.6	3 615	33.0	10 955
4. Madokchheje	8 444	29.6	167	0.6	5 491	19.2	14 437	50.6	28 539
SUB-TOTAL	30 373	29.4	749	0.7	25 206	24.4	47 075	45.5	103 403
5. Lekhuwa	8 790	46.1	546	2.9	1 307	6.9	8 402	44.1	19 045
6. Kasuwa	12 385	76.9	2 042	12.7	1 128	7.0	545	3.4	16 100
7. Leksuwa	4 600	53.2	825	9.5	2 457	28.5	759	8.8	8 641
8. Apsuwa & Waling	9 447	53.9	721	4.1	3 582	20.4	3 797	21.6	17 547
9. Ikhna	13 417	69.8	207	1.1	2 230	11.6	3 368	17.5	19 222
SUB-TOTAL	48 639	60.4	4 341	5.4	10 704	13.3	16 871	20.9	80 555
TOTAL	79 012	42.9	5 090	2.8	35 910	19.5	63 946	34.8	183 958

*Other: Ice, water, rock

Source: Shrestha (1988)

- Bhojpur and Dhankuta - and are underway in Sankhuwasabha. These surveys map, at a scale of 1:2 500, and classify, cultivated areas, adjudicate on ownership and issue certificates of registration. These certificates confirm freehold ownership, subject to the payment of annual land tax. Areas of habitation are similarly surveyed and mapped, at a scale of 1:1 250. The Private Forest Nationalisation Act 1957 and subsequent legislation affecting fallow land adjacent to forest gave Government legal control and responsibility for managing forest and much of the area of shrub and grassland - that is, most of the non-arable land, (though under the Forest Act 1961 private forest areas of up to 1.25 ha per person could be planted up.) The lack of staff in the Forest Department, however, has resulted in a failure as yet to demarcate and classify the forest and, within the Arun Basin, little work has been possible on forest inventory and working plans. Furthermore, the farming systems of the Basin depend on the use of the forest, shrub and grassland resources (see Farming Systems). Mahat *et al* (1986), referring to the middle hills of Nepal in general, have noted that government's inability to explain the law regarding forest rights to the people has led to its misinterpretation and probably also to influential individuals continuing to enjoy their past privileges. This view would apply to the Arun Basin where the local perceptions and practices of land rights owes much to historical developments.

The Arun Basin is part of the historical homeland of the Kiranti (Limbu and Rai) people. Land was traditionally owned by the community and a household's right to use it resulted from membership of a kinship group and customary occupation - a form of tenure known as *kipat*. Initially, Hindu migrants into the eastern hills in the 19th century were granted areas of unused land by the Kiranti headmen but these remained under *kipat* tenure and were subject to tribute or labour being provided to the granter (Caplan 1974). Since 1886, Government has steadily reduced the area under *kipat* tenure and it increasingly became State-owned (*raikar*), available for alienation to all communities. In 1968, all *kipat* land became convertible to *raikar* and *kipat* tenure was formally abolished in 1975. Nevertheless, it is probable that local communities still practise perceived traditional rights to exploit forest, shrub and grassland areas.

Similarly, for many generations, Government

officials, civil and military, could be rewarded with grants of rights to the land revenue of specific areas of land. Some grants, *jagir*, were subject to the annual review, *pajani*, of posts and their holders, (Stiller 1973): others, *birta*, were granted or sold to more senior officers and were notionally given in perpetuity (Conlin & Falk 1979). *Jagir* rights were abolished in 1951 and *birta* in 1962 but the practical implementation of this in terms of forest and grazing areas is uncertain.

The Land Reform Act of 1964 placed a ceiling of 4 ha, plus houselot, on the area of land that could be held by an individual (adult) in the hills. The intention was that land in excess of the ceiling would be redistributed but in the event relatively little became available; (nationally, 27 804 ha had been redistributed by 1986, ADB 1987b). Nevertheless, the question of land ownership has become a very sensitive one about which it is difficult to obtain detailed information (Conlin & Falk 1979: Kenting Earth Sciences 1987).

The Land Reform Act also made provision for the registration of tenants with security of tenure on areas up to 1 ha, subject to the regular payment of rent, the level of which was defined. No provision though was made for new tenancies nor could tenancy certificates be used as a collateral for loans. The number of formal tenancies is believed to have declined since the passing of the Act but informal tenancies may have increased. However, socio-economic studies have indicated that some large landowners were under-utilising their land because they were unable to work it themselves and were reluctant to rent it for fear that tenancy rights might later be claimed.

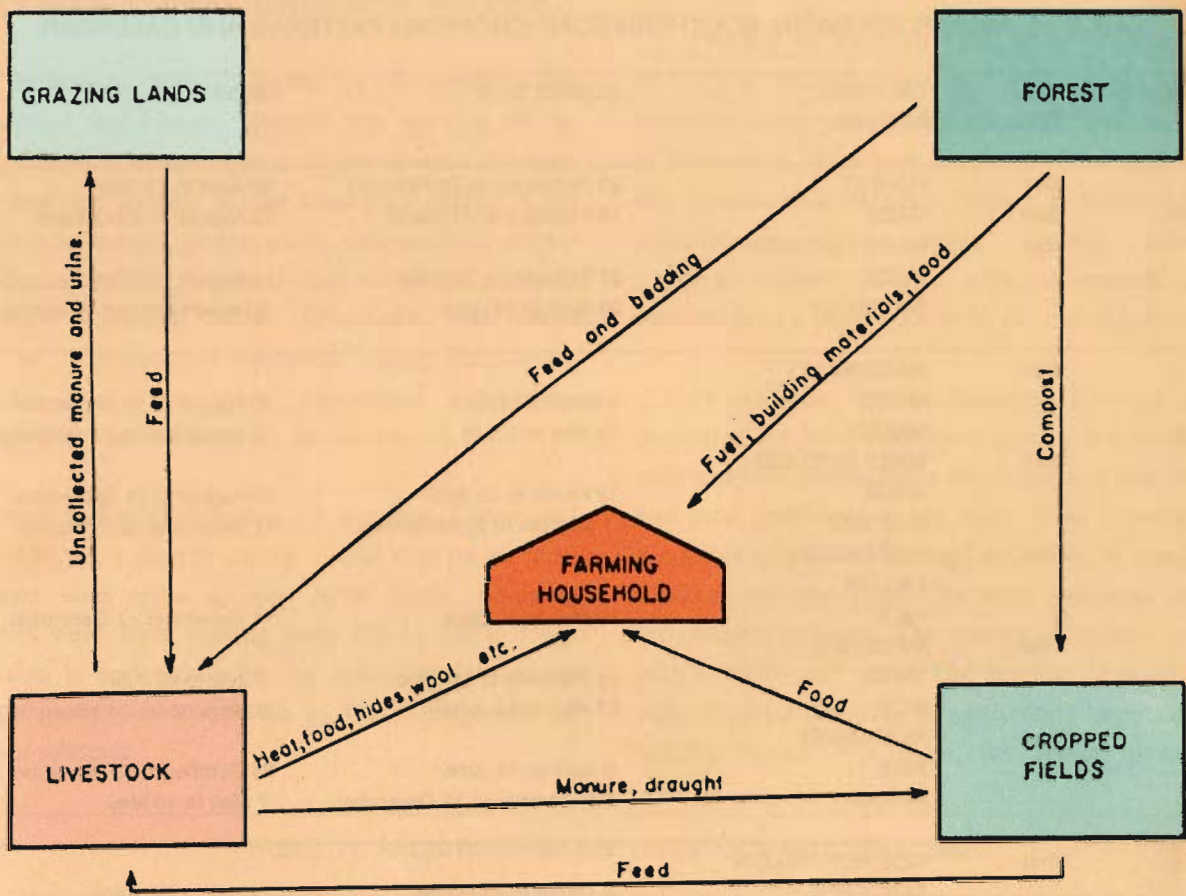
A full appreciation of both legal land rights and locally-practised usufructs has not yet been gained at local levels in the Arun Basin but is clearly essential for the achievement of improved environmental management.

Land Revenue NCR 000			
	1984/85	1985/86	1986/87
Dhankuta	374.0	383.0	335
Bhojpur	409.0	396.0	427
Sankhuwasabha	9.5	7.9	11
TOTAL	<u>792.5</u>	<u>786.9</u>	<u>773</u>

Source: Department of Land Revenue

The level of land tax levied in the Arun Basin - and

FIGURE 3 AGRICULTURE, FORESTRY AND LIVESTOCK
INTERRELATIONSHIP



Source: Hildreth (1986)

other mountain areas of Nepal - is nominal and is waived altogether for the smallest holdings. The taxes thus produce relatively little revenue for Government as is illustrated by the figures above.

FARMING SYSTEMS

Southern Zone

In spite of the great diversity of conditions within the Southern Zone of the Study Area, there is a basic farming system which involves the inter-acting relationship between crop production, livestock husbandry and the forest/ shrub/ grassland resource. The Land Resource Mapping Project (Hildreth 1986) summarized the inter-relationship diagrammatically as shown in FIGURE 3.

The system was developed in circumstances of physical isolation from any urban centre, poor communications and a sufficiency of land. It was - and largely continues to be - self-contained. Crop production is principally concerned with the growing of cereals. Rice is the preferred grain but it can only be grown on suitable soils and below an altitude of 1 700 m. The areas grown to maize and finger millet are therefore greater. Wheat has been introduced within the last decade and is sown following the main monsoon crop. At higher altitudes, above 1 700 m, the Irish potato can be an important crop. At lower altitudes, near the road, it has become a locally important winter cash crop.

The variation in agro-ecological conditions results in a range of cropping patterns: a number of the major

TABLE 10. ARUN RIVER BASIN: SOUTHERN ZONE: CROPPING PATTERNS AND CALENDAR

ALTITUDE	LAND TYPE	CROPPING PATTERN	SOWING DATE	HARVESTING DATE
HIGH	Bari	POTATO	23 December to 25 February	12 June to 12 July
	Bari	MAIZE	16 February to 21 March	23 August to 29 October
	Bari	MAIZE + SOYABEAN		
		MAIZE SOYABEAN	27 February to 30 April 25 April to 16 June	14 August to 7 October 3 September to 5 November
MID	Bari	MAIZE/MILLET		
		MAIZE	4 March to 8 April	15 August to 16 September
		MILLET	13 May to 2 July	13 November to 23 December
	Bari	MAIZE-MUSTARD		
		MAIZE MUSTARD	18 March to 25 April 1 October to 20 November	28 August to 24 September 12 December to 1 January
	Khet	RICE-FALLOW- FALLOW		
	Khet	RICE	19 May to 10 June	11 November - 1 December
		MAIZE-RICE		
	Khet	MAIZE	15 February to 15 March	7 July to 22 July
		RICE	28 May to 14 June	9 November - 24 November
RICE-WHEAT				
RICE WHEAT		8 April to 14 June 6 December to 15 December	23 October to 30 November 7 May to 10 May	
LOW	Khet	RICE-RICE-FALLOW		
		EARLY RICE	2 March to 11 March	19 July to 24 July
	Khet	MAIN RICE	16 June to 20 June	8 November to 27 November
		RICE-RICE-WHEAT		
		EARLY RICE MAIN RICE WHEAT	22 February to 13 March 20 June to 28 June 16 December to 9 January	19 July to 4 August 23 November to 5 December 10 April to 15 April

Altitude:
High - 1 700 - 2 300metres
Mid - 1 100 - 1 700 metres
Low - Below 1 100 metres

Source: Pakhribas Agricultural Centre 1988

ones are recorded in Table 10. The circumstances of the individual households varies considerably. It will be noted from Table 10 that irrigated land at lower altitudes can be cropped up to three times per year. The owners of irrigated land also tend to have larger land holdings than those with the little or no rice land. At middle altitudes, two crops per year - usually maize relay-cropped with finger millet - are common. Above 1 700 metres it may be possible to take only one crop and the yield of that be uncertain : in some cases it will be grown on small - a few square metres - terraces of shallow soils.

The household's land holding is often fragmented, though usually one plot is near the house. A smaller area near the house is also used for growing fruit, vegetables and spices (Conlin and Falk 1979). Other crops grown include mustard, soyabeans, blackgram and buckwheat.

A number of crops are grown for sale usually at the local market, *hat* bazaar, although the opening of the Dharan-Dhankuta-Basantapur road has opened an outlet in the *terai* for farmers in the Dhankuta district. Cash crops include tomato, ginger, garlic, chillies, Irish potato and tobacco. A few perennial cash crops are of local importance including citrus (mandarin and sweet orange) in Chhintang and Ankhisalla Village Panchayats, Dhankuta and the giant cardomum (*Amomum subulatum*) in Madi Mulkharka, Sankhuwasabha.

Mixed and relay cropping are common. Conlin and Falk (1979), in a sample survey, found that on all farm sizes and land types in the Arun Basin, cropping intensities were high, varying from 133 to 250%. Crop production is undertaken by the individual households although groups do cooperate in the management of irrigation schemes.

Level cultivated land is confined to the valley bottoms and comprises less than 1% of the total land area. The only level area of any size - 318 hectares - occurs at Tumlingtar, Sankhuwasabha. Essentially, therefore, cultivation takes place on terraced hillsides. The terraces are broadly divided into 'level' and 'sloping'. Level terraces include those prepared where the soils have good water-holding capacity - *khet* land - and are therefore capable, usually when banded, of growing rice. Sloping terraces, *pakho* or *bari*, are said to be left with an outward slope in order to ensure rapid rainfall runoff, thus preventing the water-logging of the crop and accumulation of water in the soil to the point where it might cause landslips. On some of the steeper slopes - greater than 15 degrees - the term 'terracing' is a misnomer as the land is essentially a cleared strip of land lying along the slope.

Fertility of irrigated land, at traditional levels of production, can be maintained with the silt load of the irrigation water and possibly naturally occurring incidence of blue-green algae and *Azolla*. On the rain-fed areas, the maintenance of such fertility is dependent on its transference from other areas, either via compost/farmyard manure, tethered animals on fallow terraces fed on cut fodder or by the use of forest litter.

In addition to this function, livestock are also important for land cultivation (oxen), the production of milk and milk products for home use and sale (buffaloes) and meat (buffaloes, goats, pigs). Most households keep a number of poultry for eggs and meat. A small number of sheep are also reared for meat and wool production for clothing and rugs. The species of animals kept varies with ethnicity and caste. The keeping of small stock for sale of young offspring is particularly important for the smaller farmer. For them, the ability to exploit the

TABLE 11. ARUN RIVER BASIN: LIVESTOCK NUMBERS 1982

DISTRICT	CATTLE	BUFFALO	GOATS	SHEEP	PIGS
Bhojpur	118 969	39 895	91 026	5 077	28 043
Dhankuta	56 260	10 600	75 306	963	24 197
Sankhuwasabha	115 357	22 708	68 935	14 093	18 170
TOTAL	290 586	73 203	235 267	20 133	70 410

Source: C.B.S. 1985

resources of accessible forest, scrub and grassland is therefore of considerable significance. Fodder trees are grown specifically for livestock. Crop residues are also an important source of stock feed. The considerable areas of grassland (see Land Use) are highly prized by stock-owners but are heavily overgrazed and their productivity is low.

The number of livestock kept in the Arun Basin remains uncertain. Tables 11 and 12 show the estimates made in the 1981/82 National Sample Census for Agriculture (CBS 1985) and the 1986/87 estimates by the Ministry of Agriculture. The discrepancies are such, even allowing for different dates, as to point the need for a new census.

The two major forest products to be used are fuel and fodder. Biomass fuel is essentially the only fuel source used in the Arun Basin for cooking and heating. No estimates have been made on current levels of consumption which will vary with availability and the quantity required for heating. Mahat (1987) has noted that consumption at higher altitudes may be almost double that in lower areas. The overall average figure is probably around one cubic metre per head per year in fuel wood terms. For the Eastern Development Region as a whole it has been estimated (MFSC 1988) that annual per capita rural household fuel consumption is 829 kg (approximately 1.4 cubic metres) of which 65 kg is obtained from agricultural residues.

The quantity of fodder taken from the forest resource is not known but fodder resources are seriously inadequate in the latter part of the dry season, when crop residues have been exhausted. Fodder trees on both public and private land are then heavily over-lopped. The forest is also the source of timber, bamboo and poles used to construct houses, livestock sheds and for furniture and ploughs. Grass thatch is a common roofing

material.

Particularly for the smaller farmers, other forest products are important as supplements to the diet, (tubers, fruits, shoots, mushrooms, honey) and income, for example, medicinal plants, fibre plants and *Daphne* spp used for paper making.

The great variation in agro-climatic conditions, vegetation composition and size of land holding and the very limited data available, mean that the concept of carrying capacity and typical farm profiles could currently only be used for relatively small areas and with great circumspection within the Arun Basin.

Northern Zone

In the Northern Zone, crop cultivation is relatively less important and only 2.8% of land is recorded under agriculture (See Land Use). At lower altitudes, the cropping patterns are similar to those in the Southern Zone, but crops are grown up to 4 000 metres: at the high altitudes the main crops are naked barley, buckwheat and Irish potato (Shrestha 1988). Shifting cultivation is practised by the Sherpas (Sizeland 1986) Kumbu (Diemberger 1988) and other groups. The extent of this practice is not known. Shrestha (1988) expresses concern over the recent extension of the practice into the primary forest of the lower slopes of the Barun Valley. Elsewhere in the Zone, he records that, after felling the forest, maize and millet are grown, following which the land quickly becomes colonised by Eupatorium. Diemberger found in Tashigaon that the practice was a form of swidden agriculture. The largest trees in an area were not felled and following the taking of one crop, the land was left fallow for 7-8 years.

Above 3 000 metres, transhumant stock husbandry is practised. Yaks and their crosses are kept for milk, ghee, wool, hides and as pack animals, sheep and goats

TABLE 12. ARUN RIVER BASIN STUDY: LIVESTOCK NUMBERS. 1986/87

DISTRICT	CATTLE	BUFFALO	GOATS	SHEEP	PIGS
Bhojpur	95 600	44 675	132 437	24 045	33 410
Dhankuta	56 602	18 965	90 696	1 565	17 892
Sankhuwasabha	78 012	18 112	78 494	15 380	15 169
TOTAL	230 214	81 752	301 627	40 990	66 471

Source: Agricultural Statistics Division
Ministry of Agriculture

for meat and wool. Methods of stock raising in northern Sankhuwasabha have been little studied. Humphrey (1980), in a survey of Chepuwa, Hatiya and Kimathanka, which also included a brief review of sheep-keeping in the Angla-Sekhaya area, identified the following forms of stock keeping.

- A. The nomadic herdsmen - "d(r)og-pa - of whom some were found in Kimathanka and others in Thudam . They herd yaks, cattle and their crosses. The report records that "formerly, before the border with Tibet was closed, there were much larger numbers" of these herdsmen but many stayed in Tibet. Such herdsman, including Sherpas, were also reported from Makalu. (Kimathanka was thought to be the only place where there are "large numbers of yaks".)
- B. Farmer herdsmen - sa-mad(r)og - settled farmers with relatively smallscale herding of sheep and chauries (yak crosses). They were recorded in Hong Gong, Gomba, Ridak and Chumisur.
- C. Farmer / agriculturists - shing-sa-wa - with cattle and sheep following mixed farming systems similar to those in the south.
- D. Gurung sheep farmers - also called d(r)og-pa - particularly from Angla (over 3 000 head) and Sekaya (Pangma Village Panchayat) (2 500 - 3 000 head). Seduwa was also thought to have many head of stock with Sherpas and others owning sheep flocks and chauries. Other owners were reported in Mangmya and Pakhribas.

The people of Tashigaun graze their mixed livestock on summer grazing near Makalu base camp and, in winter, in the lower areas of the Kasuwa river sub-catchment (Diemburger 1988). Both Shrestha (1988) and Sizeland (1986) report considerable damage to forest by grazing animals. This is particularly so between 2 500 and 3 000 metres, which is exploited by high altitude herds in winter and lower altitude livestock during the summer and monsoon.

The lack of aerial photographs makes it difficult to assess accurately the situation in the Northern Zone.

Availability of Arable Land

Figures from different sources for the area of arable land can vary considerably according to the definition of the term (Hildreth 1986) and the method used for the estimation. For the Arun Basin, Southern Zone, the best available data for arable land per Village Panchayat is found in Stewart (1987). Figures for areas with 80-90 % and over 90% cultivation are recorded, based on aerial photograph interpretation (1978 Panchromatic, scale approximately 1:20 000). Using the data for each Village Panchayat together with 1981 population census figures for the Panchayats, the population density per square kilometre of agricultural land has been calculated. These data have been summarised by District and density category in TABLE 13.

From this, it will be noted that six Village Panchayats have populations per square kilometre of agricultural land in excess of 500 and a further 13, populations between 400 and 499. They are listed in TABLE 14. In considering these data it will be noted that

TABLE 13. ARUN RIVER BASIN STUDY: SUMMARY - POPULATION PER KM² AGRICULTURAL LAND BY VILLAGE PANCHAYAT

Density Category Population/km ²	DISTRICT			
	Bhojpur	Dhankuta	Sankhuwasabha	TOTAL
100-199	3	1	1	6
200-299	19	16	13	49
300-399	27	13	7	45
400-499	9	4	-	13
500 +	4	2	-	6
TOTAL	62	36	21*	119

Source: Sharma (1988), Stewart (1987)

*Khatamma and Chauki Danda are treated as one
Data for other panchayats are either not available or incomplete

TABLE 14: ARUN RIVER BASIN STUDY: VILLAGE PANCHAYATS WITH POPULATION DENSITIES PER KM² OF AGRICULTURAL LAND EXCEEDING 400

500 +		400 - 499	
Bhojpur District		Bhojpur District	
Bhojpur x	Bhulke		Thulodumme
Pawala	Khatamachha		Timma
Shyamsila x	Kot Danda		Yaku
Taksar x	Okhre		Yun
	Ranibas		
Dhankuta District		Dhankuta District	
Dhankuta T.P.x	Budhimorang		Mudebas
Bhedetar	Danda Bazaar		Pakhribas

four, those marked thus x, are panchayats with major urban centres or are close to them. It should also be appreciated that Village Panchayat boundaries are not necessarily coincident with the areas of agricultural land available to the residents: thus pressure on agricultural land within any given Village Panchayat will be affected by the availability to residents of such land outside the Panchayat and conversely the extent to which outsiders have land rights in the Panchayat. Again, the calculation also presupposes that the census data are reasonably accurate at the individual Village Panchayat level.

The availability of land - owned or rented - to the individual household varies substantially. In their sample survey of households in the Koshi hill districts (that is, the Arun Basin together with Terhathum), Conlin and Falk (1979) found the distribution as shown in TABLE 15. From this it will be seen that 43% of households had 0.5 hectares or less available and together cultivated only 14.8 % of the total cultivated area. A further 30.6% cultivated 0.51 to 1.0 hectare or 25.9% of the total area. By contrast, 15% of households had available 44.4% of the total area, each cultivating over 1.5 hectares. The distribution is distorted further by the fact that the

larger farmers control a disproportionate amount of the better quality land, particularly irrigated land. The National Sample Census of Agriculture 1981-82 (CBS 1985) estimated that, in the Arun River Basin, 14% of the cultivated land had seasonal irrigation and 2.6% perennial irrigation.

The great majority of farm households own at least some land: the National Sample Census of Agriculture 1981-82 - based on a random sample of 50 wards per District - did not record any households with only rented land in Bhojpur; in Dhankuta, they estimated there were 104 such holdings totalling 163 hectares and in Sankhuwasabha 245 households cultivating 94 hectares (CBS 1985). The number of households who rent land to augment their own holdings is substantially higher. The Census estimated that 5 187 households in the Arun Basin rented a total of 2 803 hectares: they also cultivated 6 832 hectares of their own land. The figures for the area rented are probably underestimated. There is a reluctance on the part of the land-owners to disclose the details of the land they rent out. Again, there is a sensitivity about mortgaged land (Conlin and Falk 1979). The Census estimated that, of the types of

TABLE 15. ARUN BASIN STUDY.KOSHI HILL DISTRICTS. LAND - OWNED OR RENTED - AVAILABLE FOR CULTIVATION PER HOUSEHOLD

FARM SIZE (Hectares)	PERCENTAGE OF FARMS	PERCENTAGE OF TOTAL AREA
0 - 0.25	19.8	3.7
0.26 - 0.5	23.5	11.1
0.51 - 1.0	30.6	25.9
1.01 - 1.5	11.1	14.9
1.51 +	15.0	44.4

Source: Conlin & Falk (1979)

TABLE 16. FRAGMENTATION OF LAND HOLDINGS:NUMBER OF PARCELS/HOLDING.

DISTRICT	Percent					Average
	Number of parcels per holding					
	1	2-3	4-5	6-9	>9	
Bhojpur	16.5	51.5	22.2	8.2	2.0	4.0
Dhankuta	50.4	29.2	13.3	5.7	1.4	2.4
Sankhuwasabha	36.5	43.2	9.5	7.8	3.0	2.9

Source: CBS (1985)

rent, 56% by number, 43% by area, was share-cropped (usually 50% of the main crop) and 11% by number, 23% by area, rented for a fixed quantity of produce. Clearly, in both instances, the produce available to the family is only a proportion of that obtained from the same area of owned land.

It is usual for a family's land holding to be fragmented. Estimates of this for the three Districts by the Sample Census are given in TABLE 16. The figure of 50.4 % of single parcel holdings in Dhankuta is surprisingly high. Conlin and Falk (1979) found that parcel size tended to increase with an increase of total holding size: the averages were 0.09 hectares for small farms (less than 0.5 hectares), 0.16 hectares for middle sized farms, (0.51 to 1.0 hectare) and 0.35 hectares with farms over 1 hectare. The disadvantages of fragmentation were considered to be the diminution of the management capability, particularly in the control of pests and diseases and theft problems, as well as the time lost walking from one parcel to another, for which an average figure of 30 minutes was suggested. To offset these disadvantages, there may be gains in terms of variations in cropping patterns and thus in the risk of crop failure, and also a consequent spread of labour requirements due to different micro-climatic conditions of the parcels.

The National Sample Census of Agriculture 1981/82 (CBS 1985) estimated an almost negligible level of rural landlessness in the Arun Basin at only 0.1 % - 76 households out of a total of 74 235. The national average was estimated to be 0.37 %. This remarkably low figure may be accounted for, to a degree, by the nearly literal definition of landlessness as a household owning or leasing less than 0.01 ha or having fewer than two head of cattle / buffalo, five head of sheep or goats or 20 poultry. Using these criteria, landholding households must include many who gain only a minor proportion of

their subsistence needs from their holding. It may be noted that FAO define landless households as those whose holdings supply less than 20 % of the poverty-level income or less than 10 % of the average per capita income of the country.

The Condition of the Natural Resources of the Arun Basin

No studies have been undertaken in the Arun Basin on changes in the condition of the natural resources over time. There is thus no quantitative data to support the widely accepted view that the situation is deteriorating as a result of a growing population using the resources on a scale greater than can be sustained under present systems of management.

Shrestha *et al* (1983) assessed the watershed conditions in each District of the Kingdom on the basis of the state of their constituent Land Systems: factors taken into account were geology, topography, climate, vegetative cover and the extent of natural and accelerated erosion. The position in Sankhuwasabha was assessed as "good" and in the other two Districts as "fairly good". Nevertheless, aspects of the review of the vegetation and land use in the Basin (q.v.) indicate areas of concern. Mention has already been made of the high proportion of land under forest with a canopy closure of 20-50 % or under grassland/Eupatorium: together they cover some 27 % of Bhojpur, Dhankuta and southern Sankhuwasabha and are indicative of the need to improve the management of such areas.

Soil loss from well-managed irrigation schemes should be minimal and indeed such areas may benefit both from nutrients brought down in the irrigation water and from the presence of blue-green algae and Azolla. Nevertheless, the system of water management within schemes commonly results in prodigal use of water and

poor internal control. Canal failure is also common and can cause landslips and gully erosion.

There are no recorded data on long term changes in crop yields or losses of soil and nutrients from traditionally-managed rainfed outwardly sloping terraces. Nevertheless, it is rare to see any soil or water conservation practices on such areas and sheet erosion with loss of top soil and nutrients must be inevitable.

The burning of forest litter and grassland by stockmen during the dry season to encourage fresh growth for grazing is a common practice and leads to a deterioration in the carrying capacity of the grazing areas as well as damage to the forest resource.

Reference has been made earlier (Medicinal Plants) to the over-exploitation of the naturally occurring medicinal plants, to the point where several face extinction.

Grazing livestock almost certainly slow regeneration of forest through the destruction of seedlings and coppice growth and accelerate surface erosion in over-grazed areas.

It has been stated, on the basis of aerial photograph interpretation, that there has been negligible deforestation in the middle and high mountain areas of Nepal between 1964 and 1986 (WECS 1986; MFSC 1988). This statement must be qualified to a degree for the Arun Basin in view of Bajracharya's (1981) report of land clearing for cultivation in Pangma, Sankhuwasabha and Khadka's (1987) and Shrestha's (1988) records of continuing shifting cultivation in northern Sankhuwasabha, the scale of which is not known.

The potential for natural revegetation of degraded areas is notable, even on the northern (dry) slopes of the Siwaliks in the south of the Study Area. The severe erosion - gullying and land slips - resulting from poor layout, design and construction of a road in the area (Carson 1985) slowly greened over in the course of several years. At Pakhribas Agricultural Centre, the fencing of the upland grazing area led quickly to the strong growth of grasses and forbs. There has been a similar response where areas have been fenced off for forest plantation (Panchayat Forest), except on areas of

bare red soils (*rato mato*) : here *Pinus roxburghii* can be planted as a pioneer species, but sheet erosion will continue for some years unless contour lines of grasses or shrubs are also established. Similarly, the productivity of forest areas with reduced canopy closure (20-50%) can be increased by a factor of several-fold by improved management including enrichment planting. The methods whereby this might be achieved, through the Panchayat Protected Forest scheme, is considered later in this Study.

Better soil and water conservation on irrigated areas can be achieved on most existing schemes, through the substitution of known improved technologies for traditional methods, particularly in unstable zones-difficult intake sites, cross-drainage sites and seepage zones (Gowing 1985). Water management within the cultivated areas can also be much improved. On rainfed cultivated areas the techniques of soil conservation are known and have been successfully implemented elsewhere in the Kingdom, for example in Kakani Village Panchayat, Nuwakot District.

The sustainability of the farming systems involving rainfed crop production requires an appropriate balance between the areas of cultivated land, number of livestock and the forest / shrub / grassland resource. The achievement of this at the individual household level is one of the most intractable problems in environmental management in the Arun Basin and its resolution will not be easy.

OFF FARM ECONOMIC ACTIVITIES

Wage Employment

The most usual means of augmenting farm incomes is to undertake wage employment on other farms. Work may also be obtained, particularly by those with a skill, in the construction of houses and other buildings or on development projects. Between 1980 and 1985 KHARDEP (q.v.) disbursed over 250 lakhs of rupees on buildings in the four Koshi hill districts. The construction of the Dhankuta-Hile-Basantapur road has given substantial wage employment to local people since 1976. Between 1980 and 1986, work on the Dhankuta - Basantapur road brought in the region of 360 lakhs of rupees to local contractors and men and women workers. More traditionally, seasonal work as porters is undertaken by members of the poorer households.

The expansion of the government service has opened up a number of permanent, mainly junior grade, posts to local residents which may ease the situation of their household.

Caste Occupations

Among the Hindu groups, it is common for men to follow their caste occupation in addition to farming. Thus a number of Brahmins will officiate as priests and thereby augment their farm income.

It has been noted earlier that the Hindu occupational castes are found throughout much of the Arun Basin. Many of them have small land holdings on which they farm but, in addition they will follow their traditional occupation - shoemaker, tailor, blacksmith - for which they would be paid either in cash or kind. Similarly, in Chainpur, Sankhuwasabha, and Taksar, Bhojpur, numbers of Newar families follow a traditional occupation of brassworker. For a proportion this will be a full time occupation and not undertaken in addition to farming.

Natural Products

Mention has been made earlier of the importance to some of the poorer households at high altitudes of the income obtained from the collection and sale of medicinal plants, spices e.g. *Cinnamomum tamala* and lichens.

Near urban centres, the collection and sale of firewood, usually by women, is common. Seasonally and locally the sale of fuelwood to brick kilns is practised.

Cottage Industries

Rural households have traditionally themselves made many of the items required by the family, using materials available locally: these include mats and baskets from bamboo, straw or grass, cooking pots from clay, clothing, blankets and rugs from wool, cotton and other fibres. A number of these, particularly storage and carrying baskets, headbands and pottery, are sold in local markets and provide a useful source of income. A range of the items are both functional and beautiful and demonstrate the highest standard of craftsmanship. By adapting traditional products for alternative uses to make items such as cloth, baskets, bags and embroidery, it has been demonstrated that a substantial new market could be developed in Kathmandu and overseas

(Dunsmore S, 1983,1985). Little capital input is required by the producer and the work can be undertaken without prejudice to agricultural commitments. The Arun Basin is richly endowed with skilled crafts-people - a potential that has yet to receive the support it merits in development programmes. (TEXT MAP 5)

In the Sisuwa/Sankhuwa khola area, river fish are trapped or netted and smoked. There appears to be a good market for the product both locally and elsewhere in the Koshi hills. There is probably a potential for sport fishing also but this has been little exploited to date.

Mining

There is a minor industry in parts of the Arun Basin based on locally available semi-precious stones, particularly garnet. Shrestha (1988) records that one tourmaline and aquamarine and six garnet mines have been licensed in the Chainpur area of Sankhuwasabha. All are small scale, private companies mostly locally owned and employing local labour. Excavation methods are crude.

Some stones are used locally e.g. in Hile, but most are sent to Biratnagar or Kathmandu. Shrestha records the price received in Biratnagar as R 8/kg compared with R 300 per gram for the processed stones in Kathmandu. There thus appears to be a strong case for developing much more local processing. The availability of electricity from the Arun-3 scheme might be a stimulus to this.

Migration

Seasonal and long term migration has been practised for generations and remittances from this source may be relatively substantial when a member of a household is serving with the Indian or British armies. Seasonal employment is usually sought in the *terai* or outside Nepal, particularly in Assam where work used to be obtained as labourers, wood cutters, on construction sites or in the coal mines (Cassels *et. al.* 1987). Such opportunities are now less.

Pilgrimages and Tourism

Taylor-Ide and Shrestha (1985) have recorded that "over the centuries Hindu culture has venerated the purity of the Barun river waters". In the winter, substantial numbers - Taylor-Ide and Shrestha speak of "thousands" - of pilgrims from India, China and Nepal

TEXT MAP 5

INCOME GENERATING ACTIVITIES WITH DEVELOPMENT POTENTIAL IN THE ARUN RIVER BASIN.

- L = Local Market
- H = Hotel market
- T = Tourist market
- E = Export market
- : = dotted letter = potential market.



SYMBOL	CURRENT ACTIVITIES	SUGGESTIONS	MARKET
	Dhaka cotton weaving: Topi, caps, shawls, garments	Expand production to meet market demand. Include locally produced silk and wool in dhaka range	LHTE
	Cotton cloth weaving for garments	Combine cotton with "allo" eg for furnishing and mats	LHTE
	Wool weaving for rugs (rari), garments, also carpet knitting	Improve felting facilities for "rari" Ensure sustainable wool supply	LHTE
	"Allo" weaving: traditional and new Sankhuwasabha cloth Girardinia diversifolia	Plant "allo", also under forest (soil protection) Research into improved processing	LHTE
	Embroidery: traditional motifs on shawls and other items	Expand production to meet market demand	LTE
	Paper making from lokta	Diversify sources by using e.g. bamboo and "allo"	LHTE
	Basket and mat making using bamboo, pine needles, grass, maize trash.	Plant bamboo Produce bamboo transport containers for fruit and eggs	LHT
	Metal working: ceremonial vessels, images, household goods	Improve casting facilities Ensure supply of raw material	LTE
	Semi-precious stone collecting	Process and make jewellery locally	TE
	Pottery: water jars, pots, "muckle" (heater)	Improve baking, introduce glazing Increase range of products	LHTE
	Medicinal herbs and dye-stuff collecting	Process locally	LE
	Fishing: dried smoked fish: stored and sold in bamboo baskets	Increase fish stock Improve processing facilities	LHT
	Bee keeping - honey production	Improve hives, honey processing and packaging	LHT

A survey of house holds currently involved and raw material available to them and market advice is recommended.

OTHER POTENTIAL ACTIVITIES:

- Sericulture, fish farming, goat rearing, angora rabbit rearing, cheese making (yak) mushroom cultivation,
- Food processing: eg dried ginger, scented sachets eg wild rhododendron leaves, pressed flowers for eg local paper greeting cards.

bathe at the confluence of the Barun and Arun rivers. Details of this have never been recorded.

Over the greater part of the Arun River Basin, there has been little development of tourism. An exception to this general situation involves expeditions to Mount Makalu, 8 475 metres, of which there have been 6-8 annually in the five years from 1983 to 1987; each had 5-15 climbing members, with a similar number of guides and 60-120 porters. In recording this information, Shrestha (1988) expresses concern over the situation in the "middle altitudes"-. (2 100 - 4 500 metres). With

possibly several expeditions operating simultaneously and thus perhaps several hundred porters seeking fuelwood, Rhododendron leaves for bedding and edible rhizomes and bamboo shoots, the effect on the local environment can be serious. Above the tree line, 3 600 metres. Juniper and Rhododendron shrub are used for fuel and this has led to the denudation of some areas, the natural regeneration of which is very limited. Alternative routes should be identified and used in rotation. Fuel might be obtained from old trees and dead logs available at lower elevations, otherwise it should be brought in by the parties.

Arun-3 Hydro-electric Scheme And Access Road

INTRODUCTION

It has been noted earlier that little use is currently made of the water of the Arun river and its major tributaries. Studies in recent years have, however, indicated that the hydropower potential of the Arun within Nepal is in the region of 1 185 MW. A master plan study (JICA 1985) considered how this potential could be developed and recommended a cascade of six hydropower installations. The most economical of the six, in terms of energy cost, is known as Arun-3, which has a potential maximum output of 402 MW. The Nepal Electricity Authority has forecast a need for a substantial increase in the national electricity generation capacity between 1994/95 and the end of the century. HMGN has therefore decided to proceed with the development of Arun-3 and has obtained donor support (US \$ 550 m) for the project.

The intention is to build a run-of-the-river hydropower complex consisting of a 65 metre coffer dam across the Arun river near Num, which would divert water through a desanding basin to two 11.3 km long, 7 metre diameter, tunnels running to an underground power-house at Pikhuwa (TEXT MAP 2), from where the water would return to the river. The contract for the detailed design of the complex is expected to be awarded early in 1989.

An access road to the sites of the power-house, tunnel adits and dam will be required for the construction of the complex. An alignment for this, starting near the present roadhead at Basantapur, has been selected (TEXT MAP 6). The alignment follows the ridges as far as possible but elevations vary from 2 200 to 350 metres. The total length will be some 170 km. The road will be an all-weather, gravel construction with a carriageway width of 4.5 metres on a 6.5 metre wide formation. There will be one major bridge - over the Sabahaya river at Tumlingtar - five smaller bridges and a short viaduct. Road construction can start from both Tumlingtar and Basantapur.

The contract for the construction of the road is expected to be awarded towards the end of 1988. To meet the scheduled date for the commissioning of the hydropower complex, it is planned to achieve basic access by the road within 2 1/2 years. The total road project cost is estimated to be US \$ 34.4 m, approximately US \$ 200 000/km.

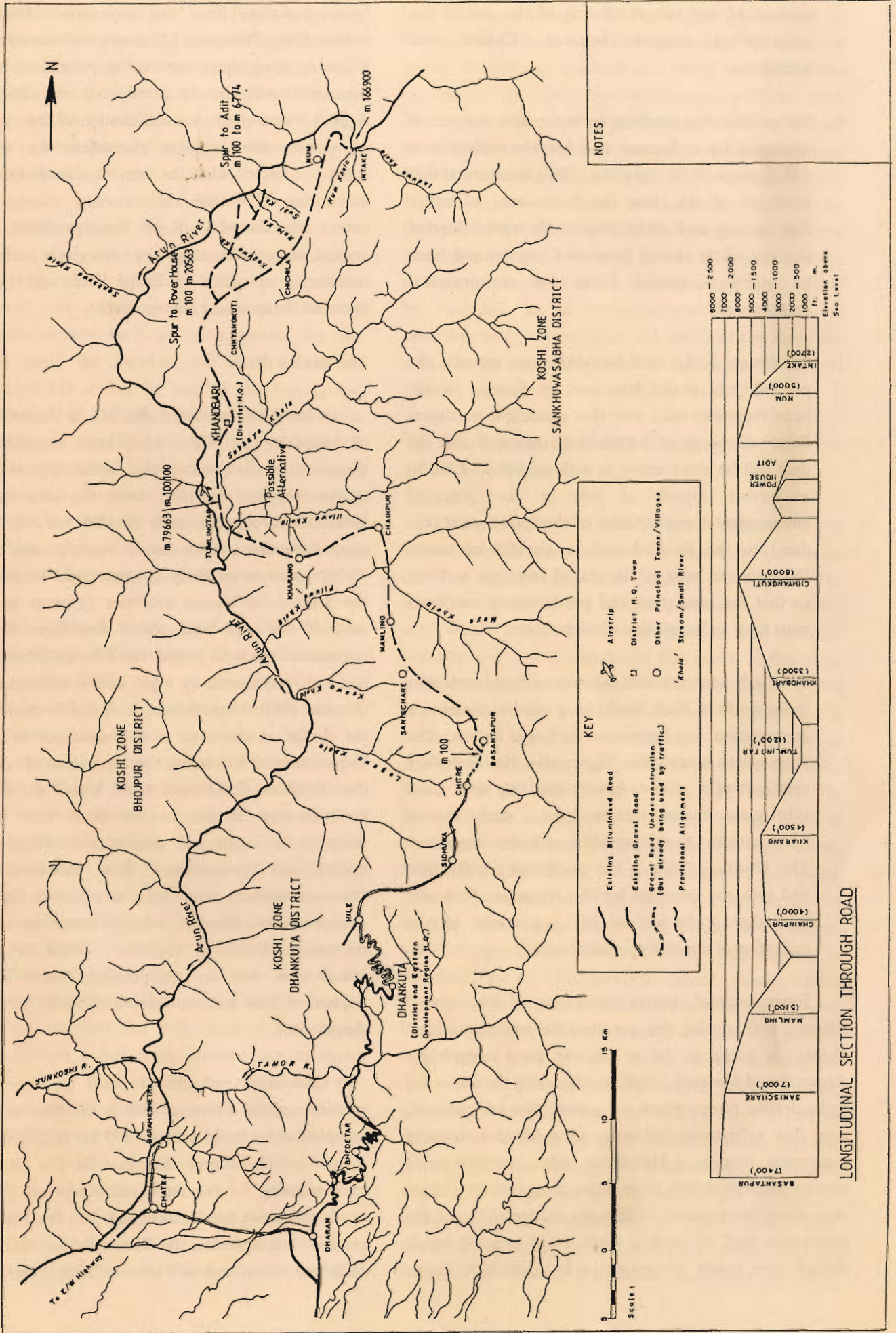
Environmental Impact and its Assessment

The Nepal Electricity Authority and the Department of Roads, together with their consultants, have been actively concerned to ensure that minimal environmental damage will result from the construction and subsequent operation of the Arun-3 hydropower scheme and the access road. Each is to establish a permanent environmental unit.

Aspects which will have to be given particular attention with regard to the hydropower complex include:

- A. the inevitable environmental disturbances resulting from the construction of the dam itself, the tunnels and the power house, including the destruction of forest, the disposal of spoil, the siting and operation of quarries, workshops and labour camps and the storage of construction materials;
- B. the less tractable effects of the dam and power house on health (particularly water-related diseases), biotic factors (plant and animal), water quality, induced seismicity and downstream hydrology, particularly between Num and Pikhuwa, the stretch affected by the diversion of the water;
- C. it has been noted earlier that little is known about the fish population of the Arun but it is believed that there is a potential to develop both table fish and sport fishing. A study will therefore be undertaken on the aquatic life of the Arun and its related tributaries in order to design a fish management plan. The study should also take

TEXT MAP 6 ARUN-3 ACCESS ROAD ALIGNMENT



account of any effects on fish of the use of the jet-propelled barges between Chatra and Tumlingtar;

- D. the backflooding resulting from the dam is expected to extend for a distance of 4 km: the surface area will be some 50 ha. Shrestha (1988) has warned that upstream of the dam site is an area of active downcutting and steep slopes. He recommended that the whole stretch between Chepuwa and Num be given a special focus for environmental management;
- E. the design of the dam has taken into account the possibility of glacial lake outburst floods. It has been suggested (JICA 1987) that a probable maximum flood discharge of $7\,700\text{m}^3/\text{s}$ be assumed and the dam will be constructed to withstand this. Clearly, a further aspect of this is the potential environmental consequence of this impediment (the dam) to the flow of such a quantity of water. Furthermore, most of the glacial lakes are in Tibet so that the prediction and prevention of outbursts must have an international component;
- F. this Study contends that the area of Sankhuwasabha to the north of Num should be treated basically as a conservation area because of its fragile nature. The proposal to extend the Sagarmatha National Park over part of it accords exactly with this view. In a subsequent section, the need for a study also of north-eastern Sankhuwasabha will be suggested. This Northern Zone is the catchment for the dam and thus the proposal for the National Park and the other study are of key importance to the operation of the hydropower complex.

Environmental impact monitoring of the Arun-3 scheme, both during the construction and operational phases, is going to be a task of great complexity. Aegerter and Messerli (1985), in discussing the impact of hydroelectric power plants on a mountain environment, note that a "rigorous balancing of a whole technology assessment remains a Herculean task..... (which) could only be attempted with some hope of success by a large, inter-disciplinary team." Within the context of Nepal, the permanent staff of such a team could only be small, though they would be supported by short-term inputs

from specialists from the appropriate Departments, corporations, Tribhuvan University and elsewhere. In the following paragraphs, aspects of environmental impact assessment will also be considered in relation to the Arun-3 access road. A consideration of the implications of environmental impact assessment for the whole Arun-3 complex and the way it interlocks with the monitoring of overall environmental change from all causes over the whole Koshi Zone produces, it will be argued, an overwhelming case for a single environmental monitoring operation at Zonal level, with linkages to both the National and District level.

The Access Road

It has been estimated that 5% of the total surface of landslides in Nepal have been created by road construction. As roads cover a surface area of 30-40 km² in the Nepalese foothills, while the area sensitive to landslides is approximately 60 000 km², it has been argued that the construction of roads creates conditions 75-100 times more likely to cause land movement than the average of human activities (ICIMOD unpublished 1986). It has also been stated that "one of the best engineered roads in Nepal, the Dharan-Dhankuta road" has had "astronomically high" annual maintenance costs (Carson 1985). Nevertheless, it should be noted that, for the design of the road from Basantapur to Num, the Department of Roads has the experience of constructing the Dhankuta to Sidhuwa road, where the detrimental environmental impact of the road itself has been minimal, in spite of intermittent breaks in the maintenance programme. The problems on the Dharan-Dhankuta road have occurred mainly on the stretch over the Siwaliks, a fragile ecosystem forming the outermost Himalayan foothills. Much of the slope failure was due to exceptionally heavy rainfall in September 1984 and, more recently, by the earthquake of August 1988.

One aspect of the proposal for the new road requires special attention: that is the time schedule for completion for basic access - 170 km in 2½ years. This is substantially shorter than that for the earlier roads, even allowing for the three starting points (Tumlingtar north and south and Basantapur). The Dharan-Dhankuta road, 50 km, including the Tamur Bridge, was started in 1976 and completed in February 1984. Construction of

the Dhankuta-Sidhuwa road, (25.5 km), began in January 1981 and the road was opened for all traffic in October 1985. Intensive labour methods were used for both these roads. With the new road, the tight schedule will demand intensive supervision to minimise environmental damage, particularly in stretches where heavy earth cutting on steep slopes or blasting of rock is involved.

The detailed design of the road involved the selection of an alignment and construction specifications that were considered optimum taking into account environmental and socio-economic factors. Additional environmental factors such as arrangements for the disposal of spoil, the location and layout of labour camps, and sources of fuel for cooking and heating and the re-vegetation of embankments etc will have been covered. With the experience in hill road construction available from the Koshi hills and elsewhere in Nepal, e.g. the Lamosangu-Jiri road (Schaffner 1987), it may be anticipated that the design and actual construction of the road will be appropriate to the conditions and implemented with the minimum environmental damage.

The area affected by the road structure itself is limited and clearly definable and the environmental consequences when traffic starts to use it will be readily identifiable. The much greater area that will be affected by the existence of the road is, by contrast, difficult to define. For example, a major cost in the collection and evacuation of medicinal plants from Sankhuwasabha and Northern Bhojpur is due to portering charges: trucking the produce from Khandbari, instead of Hile as at present, would reduce costs by perhaps NCR 2.30-3.05/kg (assuming 3-4 days at R 0.76/kg/day for the journey from Khandbari to Hile). This could stimulate demand and lead to greater exploitation of the natural stands within an area perhaps of several days trek from Khandbari. Again, in assessing the feasibility of a milk collection scheme, it was assumed that milk could be brought to roadside collection points from distances up to three hours walk. The road might also stimulate the production of other livestock products particularly slaughter stock, from a wider area for sale in the *terai* towns. These activities would affect the degree of exploitation of fodder resources over a considerable area. Reference will be made later to the possible impact of the road on the production of agricultural and horticultural crops. In Nuwakot District, vegetables have

been portered for up to 10 hours (from Kharanitar to Ranipauwa). Given adequate incentives, in terms of prices, it may be assumed that there will be similar responses to the Dhankuta-Basantapur-Num road. These, and other road-induced changes will be difficult to differentiate from environmental changes brought about by other causes and, in terms of practical response related to environmental management, there is no particular need to do so. It follows, therefore, that the consequential effects of road access as opposed to the environmental effects of the road structure itself, should be included in a comprehensive programme of environmental monitoring for the whole of the Koshi hill area - as the road will also affect activities in Terhathum District, the fourth District of the Koshi hills.

The Arun-3 project and economic activity in the Arun Basin

The objective of the Arun-3 scheme is to substantially increase capacity for electricity generation for the national grid and possibly for export. The installed capacity of the scheme is calculated to be 402 MW, which would double the present total national capacity and enable the Nepal Electricity Authority to meet forecast needs to the end of the century. The importance of the project to national development is incalculable: its effect on economic development in relation to environmental management within the Arun Basin over the next decade or two will, however, be limited by the nature of the terrain, the low level of economic activity and the absence of any large towns. Within the Koshi Zone, it can be expected that major industrial developments exploiting the electricity will be sited in the two *terai* Districts of Sunsari and Morang. Such enterprises may offer employment opportunities to migrants from the hills, and thus reduce pressure on the natural resources of the Basin: the migrants though will be in competition with residents of the *terai* and possibly neighbouring areas of India. Within the Arun Basin, the main centres of population - Dhankuta, Hile, Pakhribas, Chainpur, Khandbari, Bhojpur and Taksar - should be linked to the national grid and electricity become generally used for lighting. The degree to which it will be used for cooking and heating will clearly depend on relative cost and availability of other fuels. Some smallscale industries could also become viable, including the part - processing of medicinal herbs and processing

of agricultural products. The combination of the road and the availability of electricity might also permit the economic exploitation of natural deposits such as the limestone at Mamling and Nigale (Dhankuta), semi-precious minerals, lead and zinc near Hykule and Phakuwa and copper in the Khandbari-Phakuwa area (JICA 1987). It will be necessary to ensure that this economic development pays adequate regard to environmental aspects. (District Panchayats do not have the expertise to ensure this and arrangements for advice and inspection at Zonal level would be desirable). Nevertheless, even with all this potential, it seems probable that as many as 80 % of the population of the Arun Basin will not use electricity from the scheme during the next quarter century because of the cost and practical difficulties of extending the service to such widely scattered homes. Thus, in terms of additional or altered economic activity affecting the environment, the access road will have a greater impact on the rural population than the availability of electricity.

The command area of the Dhankuta-Basantapur-Num road includes a great range of agro-climatic conditions, from the potentially irrigable (318 ha) subtropical area at Tumlingtar (altitude 305 metres) to cool, temperate areas up to 2 500 metres: it will be possible to evacuate produce from these areas by road to the *terai* and thence to the rest of the country and to India. Some 20 species of vegetable and eleven species of tropical and subtropical fruit are expected to do well in appropriate sites (PAC 1988). The Asian Development Bank is supporting a Hill Fruit Development Project within the Arun Basin: particular emphasis will be given to citrus and also pears and peaches (ADB 1987a).

The construction of the Dhankuta-Sidhuwa road resulted in the spontaneous establishment by entrepreneurs of several orchards of temperate fruit, vegetable gardens and a considerable expansion of the area under Irish potato at elevations above 1 700 metres. Similar responses may be expected to the extension of the road to Num. Transport costs for the giant cardomum exported from Sankhuwasabha would be reduced and make the crop either more profitable or competitive. Similarly, transport costs for medicinal plants would be reduced, though this could have adverse effects through encouraging greater over-exploitation. A milk collection scheme by the Dairy Development

Corporation along the road as far as Sidhuwa was shown to be feasible: the extension of the road should enlarge the collection area and make the scheme more economic. There is no evidence of the export of firewood from the areas near the existing road to the *terai* but it must remain a possibility, which could be environmentally damaging if it depended on exploiting the existing forest resource.

However, the basically subsistence farmers of the command area will not change their current farming systems to include high value cash crops - either additionally or in substitution for present crops - nor alter their animal husbandry practices, unless they are assured that this would be beneficial to them and they had an assured market for the products. There is no organisation at present to undertake this service. A start was made some years ago on marketing studies in the Koshi hills, particularly Dhankuta District. Products with marketing potential were identified and recommendations made for the development of an agricultural marketing policy, which included the establishment of a market intelligence service and an HMGN corporation to market hill products (Jones and Innes 1982). These recommendations were not implemented nor, at the present time, is there any organisation with the responsibility for undertaking such work on the Zonal basis that is needed. Concurrently with any expansion or diversification of crop or livestock production there must be the means of ensuring that account is taken of the environmental consequences of the activities. It will therefore be suggested in the final section of this Study that marketing research and development and environmental monitoring should be two of the activities organised at Zonal level.

The extension of the road as far as Num will be a considerable stimulus to tourism, of which there is currently very little. It has been noted earlier that mountaineering parties to Makalu have caused environmental damage in Sankhuwasabha. Experience on the trekking route to the Everest base camp has also shown the harm that can be done to the environment if the development of tourism is not carefully planned. Integrated tourism, which involves the construction of small-scale lodgings built using local methods by groups of rural people and operated by them for small parties of tourists (Bilsen 1987) would seem to be most appropriate

for the area. Guidelines for the development of this activity will be needed in regard to facilities to be provided, including arrangements for waste disposal and for food and fuel. The oversight of tourism development, to ensure that it brings economic benefit to the people and avoids environmental degradation in the area, can be more effectively undertaken at Zonal level than by the individual Districts.

A noticeable feature anticipating and resulting from the building of the Dhankuta-Basantapur road was the great increase in the number of buildings by the roadside, particularly shops, and the increase in the size of the weekly *hat* bazaars along the road, where the number of itinerant traders from the *terai* became a notable feature from Dhankuta to Sidhuwa. The new building construction and the expansion of the bazaars constitute the initial stage of urbanisation which could have beneficial results if it is carefully guided. To date, expansion appears to have been spontaneous and haphazard and District Panchayats require assistance in planning, which again might be offered by the Zonal organisation.

The opening of the Dharan to Hile road substantially reduced the price of imported consumer goods in Dhankuta and Hile: these included kerosene but no studies have yet been made on the effect of this on the use of fuelwood. The road also led to the almost total loss of employment opportunities for porters between Dharan/Phusre and Hile. This effect is likely to be more widely felt with the extension of the road to Num. It has been argued that overall employment, nevertheless, would remain broadly constant, and may even increase, due to the establishment of new portering routes and greater agricultural employment (SEADD 1986). This, however, has yet to be demonstrated: it is also possible that at least a number of the porters become more dependent on exiguous landholdings on which, in consequence, there is greater environmental degradation. Such aspects of the impact of the road - and other components of the development programme - are being studied as part of the Koshi Hill Area Development Programme: in the longer term, such impact assessments could become the responsibility of the proposed Zonal organisation.

Government Administration

INTRODUCTION

The Local Administration Act of 1966 resulted in the division of the country for administration purposes into 14 Zones and 75 Districts. The three Districts of the Study Area lie in the Koshi Zone, which consists of six districts and lies between the Tibetan border in the north and the border with India in the south. The two southernmost Districts are situated largely in the *terai*, part of the Gangetic Plain. Going from north to south, the Zone includes the five physiographic divisions of Nepal - High Himalaya, High Mountain, Middle Mountain, Siwalik and Terai. Nevertheless, there is currently no developmental organization at Zonal level. Koshi Zone lies between Sagarmatha Zone to the west and Mechi Zone to the east: together the three Zones comprise the Eastern Development Region, one of the five which cover Nepal. The National Planning Commission and the major Government Departments appoint Regional Directors. There is no elected assembly at Regional or Zonal level. The Seventh Plan 1985-90 (NPC 1986) noted that proper evaluation of the existing resources and means of the Development Regions had not been undertaken but was essential for sound planning. Nevertheless, there is currently no Regional planning organization.

Apart from national level activities, the major organisation for Government activities in development is the District Panchayat.

The District Panchayat

Since the implementation of the Decentralization Act (1982) in July 1985, the District Panchayat has been responsible for the planning and the implementation of district level development projects. The organization for this is as follows.

Each District is divided into village panchayats - groups of villages or hamlets with a total population usually of 2 000 to 5 000 people. The number of Village

Panchayats in a District will vary in accordance with its total population: Bhojpur has 63, the other two Districts, 36. For election purposes the Village Panchayat has nine wards, each of which elects, by adult suffrage, five members to the Village Assembly. To these 45 members are added the presidents of five class organizations - ex-service, farmers, women, youth and elders. Village assemblies constitute the electoral college for the appointment of the President and Vice-President of the District Panchayat. The Village Panchayats are grouped into nine sub-districts, *ilaka*, and Village Assembly members of a given *ilaka* vote for their representative on the District Panchayat. Again, in addition to the President and Vice-President and nine *ilaka* members, the district presidents of the class organizations also sit on the District Panchayat.

The ward chairmen of the nine wards within a Village Panchayat, together with the presidents of the class organizations, constitute the Village Panchayat, headed by an elected *Pradhan Panch* and *Upa Pradhan Panch*. The District Assembly, consisting of all the *Pradhan Panch*, *Upa Pradhan Panch* and class organization representatives, meets annually to consider the development programme prepared by the District Panchayat.

The executive officer, (Local Development Officer) of the District Panchayat is an administrator from the Ministry of Panchayat and Local Development. The heads of the district sectoral offices provide the technical support to the Panchayat. There are thus elected assemblies and their executive groups (Panchayats) at District and Village Panchayat level and, within the Village Panchayat, ward level representatives. The intention is also to develop Service Centres with a range of Government and parastatal services in each *ilaka*, but this is still at an early stage in the Arun Basin.

The list of agencies of HMG and non-governmental organizations whose work is related to environmental management is presented in TABLE 17. The heads of the

TABLE 17. THE ARUN RIVER BASIN; AGENCIES INVOLVED WITH ENVIRONMENTAL MANAGEMENT

HMGN

Ministry of Agriculture	- Department of Agriculture *
	- Department of Livestock Development *
	- Food & Agricultural Marketing Services Dept.
Ministry of Water Resources	- Department of Irrigation.
	- Department of Hydrology & Meteorology
Ministry of Housing	- Department of Drinking Water & Sewerage
Ministry of Public Works & Transport	- Department of Roads
Ministry of Panchayat & Local Development	- District LDO/DTO *
Ministry of Forest & Soil Conservation	- Department of Forest *
Ministry of Land Reform	- Department of Land Reform
	- Department of Surveys
	- Department of Cooperatives
Ministry of Finance	- Department of Land Revenue
Ministry of Industry	- Department of Cottage and Rural Industry
National Planning Commission	- Regional Office
Ministry of Tourism	- Department of Civil Aviation

PARASTATALS

Agricultural Development Bank of Nepal
 Agricultural Inputs Corporation
 Dairy Development Corporation
 Nepal Electricity Authority

NON-GOVERNMENTAL ORGANISATIONS

CARE (trails)

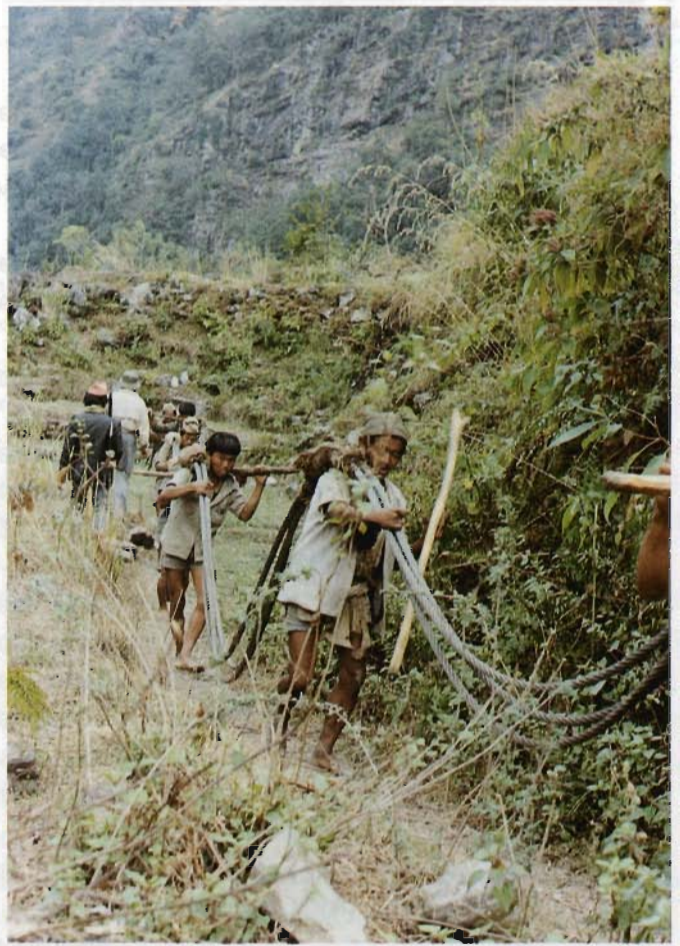
district offices marked with an * are the major technical advisers to the District Panchayat. Each has the responsibility of drafting annual sectoral plans, within guide-lines and budget ceilings defined by Central Government and taking account of the wishes of the elected representatives. Such plans are submitted first to one of the District Panchayat technical committees namely-

1. Construction and maintenance,
2. Irrigation and agriculture,
3. Industry, forestry and soil conservation,
4. Health and population,

5. Education.

Then the plans are put to a joint committee and thence to the District Panchayat, before presentation to the District Assembly for final approval.

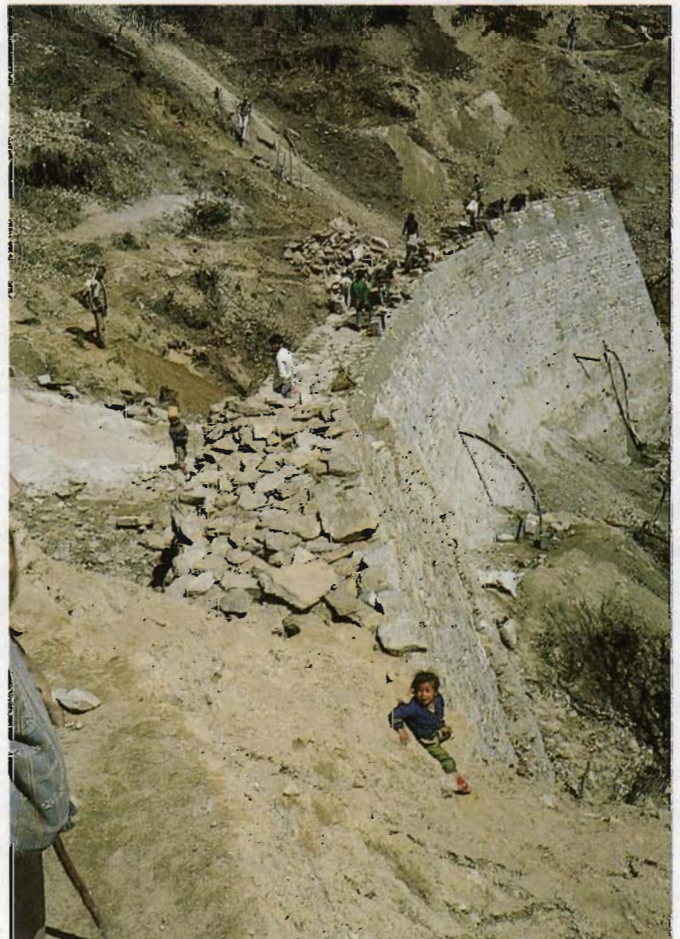
The first essential step has thus been taken in an imaginative, nationally challenging move to make planned development more appropriate and expeditious for the individual Districts. It must also be seen as a fundamental change in the role of the Government in activities in the natural resource field and, in particular, its relationship with the small local communities. This is



7.

PLATES 7 & 8: COMMUNICATIONS

7. FOOT-TRAILS. Access to most areas is by foot-trail. Porters carrying steel hawsers for a suspension bridge
8. ROAD. The first vehicular access was completed in 1984. Careful alignment, design and construction are vital in such environmentally sensitive areas



8.

discussed in the last section of this Study, together with consideration of the implications for the District Panchayat of its obligations to prepare a resource base and a perspective plan. It has been recorded (Dunsmore 1988) that Government development programmes in the districts of the Arun Basin had three components between which and within which there was little coordination. These were:

1. National Projects - major public works e.g. the Dharan-Dhankuta road.
2. Sectoral activities - which largely comprised centrally-decided quantitative targets undertaken independently by the relevant agency. e.g. areas of community forest to be planted, number of livestock to be vaccinated, number and type of farm (crop) trials laid down. These allowed little flexibility in terms of numbers and types of activities to permit response to local conditions.
3. The Panchayat sector - comprising minor public works undertaken by the panchayats using Government grants-in-aid.

There has been some change since Decentralization but annual district plans presented for approval to the District Assembly remain essentially a compilation of these individual programmes, with little consideration of co-ordination, cross-sectoral implications or specific conservation activities. The methods whereby this position could be improved on are discussed in the last part of this Study.

Koshi Hill Area Rural Development Programme (KHARDEP)

During the planning of the Dharan-Dhankuta road in the 1970s, it was appreciated that the road passed through areas of low agricultural potential, 37 of the 50 km lying in the Siwaliks. It was therefore anticipated that no significant increase in agricultural output would result solely from the construction of the road. HMGN and the United Kingdom therefore agreed to undertake a multisectoral development programme in the assumed command area of the road. In the event, the programme covered the four districts of the Koshi hills - three in the Arun Basin together with Terhathum.

Little recorded information was available on the area, so the first phase of the Programme, 1977-79, was devoted mainly to studies and surveys. The major implementation period started with phase 2, 1980-85. U.K. support, which was coordinated through a Programme Office run by the Ministry of Panchayat and Local Development, was given to the following sectors.

- a. Land use - agricultural extension, livestock services, community forestry.
- b. Local development - drinking water supply schemes, irrigation projects, trails and bridges.
- c. Roads.
- d. Education - agricultural education, teacher training.
- e. Primary health care.
- f. Cottage industries.
- g. Women's development.

An account of the activities in these sectors has been given in Dunsmore (1987). During the period 1980-85, the number of HMGN technical staff in the area rose considerably and there were substantial increases in the grants-in-aid made to District Panchayats. It can therefore be regarded as the initiation period of a major HMGN development programme for the Area, which has been continued into the current Five Year Plan (1985-1990). UK support to the programme resumed in 1987 in the sectors covering agriculture, agricultural education, livestock, community forestry and roads, together with the continuing operation of Pakhribas Agricultural Centre.

Pakhribas Agricultural Centre, 80 hectares, near Hile, was opened in 1972 to give agricultural training to former British Gurkha soldiers. Within a few years, its role changed to one of supplying training and extension services to seven local Panchayats and a similar sized area to the east lying in Taplejung and Terhathum districts. Since 1983, the Centre has developed into a resource centre for development in the Koshi hills. Its sections include agronomy, forestry and pasture, horticulture, livestock, seed technology, socio-economics, training and veterinary investigation and analytical services. In 1988, the Centre handed over its responsibility for agricultural extension to the Department of Agriculture.

Experience in other countries (see, for example,

Morris and Gwyer 1983) has demonstrated that development programmes in the natural resource field have failed to meet their objectives because of

- Lack of knowledge of existing farming systems
- Failure to test new technology adequately on farmers' fields
- Unrealistic assumptions of benefits of proposed changes
- Attempting to introduce activities which were unattractive to the farmers, and
- Giving insufficient consideration to sociological aspects.

Pakhribas, with its inter-disciplinary approach, its work on farmers fields and its linkages with National programmes and with district sectoral agencies, is able to play a major role in the avoidance of these deficiencies.

Basic Needs Directive

By a Directive of His Majesty the King in 1985, all Nepalese people should be provided with the basic needs of food, clothes, shelter, education, health and security, in conformity with the Asian standards, by the year 2000 A.D. The standards for the mountain areas were quantified as follows (NPC 1987):

- | | |
|-------------|--|
| - Food | - 2 340 calories per head per day |
| - Cloth | - 10.3 - 12.7 metres per head per year |
| - Shelter | - 40 - 60 square metres per family of floor space, including kitchen, toilet and drinking water facilities |
| - Education | - free primary education for all children of ages 6-10, classes 1-5 |
| - Health | - Primary health care services and health education. One hospital per district, one health post per <i>ilaka</i> |
| - Security | - interpreted in its broadest sense |

The target group for the implementation of this Directive are people below the absolute poverty level (US \$ 92 per head per year).

Implementing this Directive is now a priority task and in mid-1988 teams undertook surveys at Village Panchayat ward level to identify the number of families in each who are in the target group. The intention then will be to identify suitable projects to enable them to obtain their basic needs by the year 2000. The number of families affected in the Arun Basin is not yet known. It is likely to be above the national average of 42%. Given the relatively short time for the implementation of the Directive, it could undoubtedly absorb a considerable proportion of the development effort of the District Panchayats over the next decade.

Part 2. Increasing the Effectiveness of the Environmental Management System

INTRODUCTION

The environmental assessment recorded earlier in this Study has indicated that, in the Arun River Basin, economic development of the natural resources with adequate consideration of conservation aspects requires well-informed, coordinated and sensitive Government support. The framework for this now exists as a result of the Decentralisation Act, under which responsibility for District-level planning and implementation is given to the District Panchayat (see GOVERNMENT ADMINISTRATION).

The objective of Decentralisation is to make Government support to development, particularly in the field of natural resources, more appropriate for the individual Districts, identifying and expanding their potential and designing suitable projects to deal with areas of particular need or of environmental sensitivity. In undertaking this work in the field of environmental management there is a general recognition that the scale of activities that must be completed is so vast and it is of such a nature that the role of Government can only be a subsidiary one to that of the people and the communities, who are, and must remain, the chief managers. The role of Government then becomes one of technical adviser, particularly introducing appropriate new technologies and the related inputs, including credit, and either supplying - e.g. roads, trails - or supporting - e.g. markets - the development of necessary infrastructure, organising training courses, monitoring the overall environmental situation and most fundamental of all, identifying and assisting the various "user groups". Taking this as the starting point, this chapter identifies the means whereby environmental management for both economic development and conservation can be improved through more effective activities of the District Panchayat, the sectoral agencies, the local communities, women and sub-regional (Zonal) programmes. These means are considered under the following headings:

1. The resource base/Geographic Information Systems
2. Development planning - perspective and annual
- prioritisation
3. The community or "user group "
4. The role of women
5. Conservation
6. Sub-regional (Zonal) activities

In considering appropriate roles and tools for undertaking this work, it has been borne in mind that there is little prospect of any substantial increase in the numbers of professional staff above the present approved level. As far as possible, therefore, any additional work has been designed as a realistic component of the duties of existing staff.

It will then be argued that there is a need to define a role for a sub-regional (Zonal) organisation that can undertake activities at a supra-district level and be responsible for such aspects as inter-district communications, marketing studies, environmental monitoring and evaluation and impact assessment.

The Resource Base/Geographic Information Systems

Both for the design of the individual sectoral programmes and for the consideration of cross-sectoral, including environmental conservation, aspects, it is clearly essential to have a comprehensive knowledge of the resources of the District. This is largely lacking in the Arun Basin at the present time. Thus there is no record of the present composition, condition or ownership of the forest, scrub and grassland resources, current livestock numbers and productivity are not known with any degree of accuracy, the water resources of the Basin - particularly small streams and springs on which most drinking water supply schemes and irrigation projects would depend - have not been mapped nor their productivity estimated.

The National Land Use Planning Project (ADB 1987b) outlined the range of information that was required as follows:

A. Environmental

- Climate (rainfall, temperature, frost risk, windspeed, relative humidity, radiation, pan evaporation, growing season)
- Maps of
 - landform
 - land capability
 - groundwater and surface water sources

B. Present land use and vegetative cover

- arable land
 - rainfed
 - irrigated
 - perennial
 - seasonal

Preferably recording ownership, tenancies and farming systems

- forest
 - types (including orchard and canopy closure)
- ownership
 - National (including protected forest and wilderness areas)
 - Private
 - Panchayat
 - Panchayat Protected
 - Guthi (religious trust)

C. Livestock

- types: herd/flock structure,
- husbandry methods
- fodder and forage resources
- ownership/herding arrangements
- uses: product marketing

D. Infrastructure and services. Contour maps showing:

- *ilaka*, panchayat and ward boundaries
- roads, trails, bridges, ferries,
- airfields /strips
- Service Centres,
- Input Corporation and cooperative godowns
- hospitals and health posts
- markets
 - permanent and periodic

E. Socio-economic

- Population, by Village Panchayat ward, ethnic group, sex, age and household
- economic activity-
 - permanent
 - seasonal
 - migratory
- land
 - ownership and tenancy

F. Other land uses

- urban/village habitation areas
- landslips/slides
- rocky outcrops
- other non-productive areas
- areas subject to particular erosion hazards
- quarries and mines

This appears to be a formidable list but much of the information is, or could become, available from the different agencies. A major exception though will be changes over time of the main resources - forest, grassland, scrub, cultivated land - for which periodic surveys will be needed. The methods whereby this might be done will be considered later. For the other data and information, once the needs have been defined and responsibility for their compilation and updating allocated, in most cases their collection could become a routine task. Thus, climatic data are available from the Department of Hydrology and Meteorology, Department of Roads, Pakhribas and the Department of Civil Aviation. The Livestock Department, with its expanding staff numbers, is now in a position to gather data on livestock. Demographic data could be obtained by Village Panchayat Secretaries.

For the Southern Zone of the Basin, contour maps (1:25 000; contours 100 foot intervals) are already available showing rivers, roads, major trails, bridges, major habitations, Government and Non-Governmental Organisation service structures and district, panchayat and some ward boundaries. Using these maps as a base, forest and land use types have been mapped, following interpretation of aerial photography (see LAND USE). Contour maps (1:50 000) are available for the Northern Zone.

Cadastral surveys have been completed in Dhankuta and Bhojpur and are in progress in Sankhuwasabha. These surveyed, mapped and classified all cultivated land and granted certificates of registration to the owners. The information is mapped at a scale of 1:2 500. (Ownership in settlement and urban areas is recorded on maps at a scale of 1:1 250).

It will be contended later (User Groups) that a fundamental requirement for sustainable agriculture in the Arun Basin is the resolution of the question of

management responsibilities for the forest, scrub and grassland areas.

The Arun and its major tributaries are of very limited use for drinking water and irrigation schemes, as there are few habitations or cultivated land areas that can be served by gravity flow and the cost of pumping is currently prohibitive. The principal sources of water - potable and irrigation - are therefore small streams, springs and wells. The sites and yields of these have never been recorded. It is clearly important that they should be so, together with any traditional rights pertaining to them, in view of the understandable priority given to drinking water and irrigation projects by the Panchayats. This will be a considerable task - there are believed to be at least 250 irrigation schemes in Dhankuta District alone and innumerable sources of drinking water. An inventory of these will take time to compile; it can probably best be done at ward level with ward members preparing a preliminary list of sources within their own areas.

No government agency currently has responsibility specifically for monitoring the condition of trails and their related bridges, although these are the arteries of trade and communication for much of the Basin. In consequence, the state of many stretches of trails is poor and travel, particularly for laden porters during the monsoon, can be dangerous. For the major trails, connecting the Districts and the *terai*, this task could best be done on a sub-regional basis to which reference is made later. For other trails, it would be suitable for Village Panchayat secretaries.

The concept of a resource base and cross-sectoral consideration of development priorities will be a new one to most District Panchayat members - and to a majority of district technical staff. It would therefore be helpful to use the 1:25 000 maps to display at Village Panchayat and District level as much of the information as possible. The aim would be to give members a spatial concept of the resources and areas of concern. Thus the map could identify such information as the panchayats/wards with a high agricultural density or heavy exploitation of the forest resource, record stretches of trails which are in poor condition, note places where there is a particular erosion hazard. The system would also identify areas with a potential for

increased production, for example through the proximity of level terraces and an exploitable water resource. Such maps could be augmented by aerial photographs or photomosaics, where appropriate. Thematic overlays would help to reduce the possibility of the map becoming confusingly full of information. This is a straightforward, easily implementable approach that could be undertaken immediately with little augmentation of existing resources. It could give to the panchayat member a broader perspective than a narrow, constituency-based outlook, encourage technical staff to appreciate other demands than their own on the resource base and give to both groups a developing appreciation of cross-sectoral and conservation aspects of environmental management.

The collection and maintenance of the range of information, data, thematic maps and overlays discussed in this section will constitute a manual Geographic Information System (GIS). This can be readily modified for the introduction of micro-computers at District level, which should be anticipated, particularly in Dhankuta, within a few years. An indication of what might be undertaken using such techniques has been demonstrated by Shah *et al* (1987) in their resource evaluation of the Dhankuta district. This was based on the reconnaissance level data of the Land Resource Mapping Project and the report noted the inadequacy of the data. It was defined therefore as a resource overview for district planning, identifying potential and problems: "it is not to be used as a planning source for land management and planning at the village level, for which more detailed information is required." Nevertheless, it is a useful example of the value of such techniques in gaining a comprehensive understanding of the resource situation. It also re-emphasises the value of having current and accurate data.

Development Planning - Annual and Perspective

The preparation of a reliable resource base is the first essential step in sound environmental management planning. It should lead to the preparation of a perspective plan and indeed this is required by the Decentralisation Act from each District Panchayat. Each District Panchayat has a Planning Officer - an administrative officer of the Ministry of Panchayat and Local Development; one of the incumbents (1988) of

such a post in the Arun Basin was trained as an economist but it would be more usual for the post to be held by someone without a technical background and with only limited planning experience. Again, the heads of the District technical departments seldom have planning training, although they are experienced in preparing annual plans for their sectors on the basis of objectives and targets from their Departments and their own appreciation of the situation in their District. As a group, the Local Development Officer, the Planning Officer and the heads of technical departments should be able to generate discussions leading to much fuller understanding of the conditions in the District - its potentials and its problems.

Nevertheless, support in the planning procedures, collating all the information and taking into account the socio-economic, cross-sectoral and conservation aspects will be needed. Within the Government service, there are probably adequate numbers of staff with appropriate training for this work if, nationally, it were undertaken initially in selected Districts: within the Arun Basin, this should be Dhankuta, where assistance is already being received from the UK-supported Koshi Hill Development Programme.

Prioritisation

One of the weaknesses of the present District planning methods lies in the area of project identification and prioritisation. This may be illustrated by the following instance concerning small-scale public works.

In 2044/45 (1987/88) the Dhankuta District Panchayat was allocated R16 lakhs as grants-in-aid. Of this sum, R6.4 lakhs was assigned for administrative expenses, educational purposes, scheme maintenance and disaster/emergency work. The balance - R9.6 lakhs - was available for small-scale public works, to be selected by the District Panchayat. Of these, drinking water supply schemes and irrigation projects are the most popular. Government requires that at least 50% of the funds be spent on Village Panchayat-level activities: in the case of Dhankuta, the proportion is usually 60-65%. Each of the 36 Village Panchayats will submit requests for schemes, possibly indeed up to four each. These should be subject to pre-feasibility studies but this is a practical impossibility, (the staff of the District Technical

Office consists of one engineer and six overseers).

Understandably, each Village Panchayat wishes to have at least one new scheme each year, the execution of which may well run over into a second year. In these circumstances, the problem of inadequate technical and financial inputs is difficult to avoid. In the past such situations have been exacerbated by a failure to fully involve the community or beneficiaries group concerned from the earliest stages of the project and essential community support has been lacking (Dunsmore 1987).

Again, in terms of the sectoral programmes, there has been only limited prioritisation of activities on the basis of specific needs. Abell (1981) identified a number of Village Panchayats in the Arun Basin as most in need of a forestry programme: this was done on the basis of identifying, using aerial photographs, those Village Panchayats with a high intensity of cultivation (and thus limited forest resource) or because of a higher incidence of landslips than generally found. This has yet to be taken into account in community forestry planning. Similarly, the particular needs of those Village Panchayats with a high population:agricultural land ratio (see LAND USE) should be taken into account. Again, the relatively greater dependence of the small farmer on livestock should make this group the main target for activities in that field. Prioritisation in relation to the needs of women will be discussed in a later section.

In all these instances there is a need for the professional staff to decide, on the basis of their staff and financial resources, what the limits of their capabilities will be for the year being planned and the Plan's projects should be confined to this. This proposal is unlikely to be easy to implement; politicians universally wishing to produce tangible benefits for their constituents. Nevertheless, it is of major importance over the next few years, while the confidence of the people is being won for the development process.

The Community or "User Groups"

In its rural development proposals, HMGN lays considerable stress on community participation: such participation is undoubtedly vital. Experience in the Koshi hills has demonstrated that, to be successful, such an approach must identify specifically who the

"community" or beneficiaries will be in any given project. There is still a tendency to equate "community" with Village Panchayat, a belief that reduced the effectiveness of a number of projects during KHARDEP Phase 2. The Village Panchayat has a clear role in the development process but it is not a suitable level for the practical implementation of individual projects. The boundaries of Village Panchayats are of recent origin and are subject to change. In the Arun Basin, rural Village Panchayat populations (1981) range between 309 (Kimathanka) to 1 591 (Sidrang) to 5 990 (Ranibas) and their area, with great agro-ecological variation, from the 7.21 km² of Shyamsila to the great expanse of Makalu Village Panchayat. Thus the Village Panchayat is too large and heterogeneous a group and too diverse an area to be considered as a "community" for projects involving directly no more than a few score households or fewer. Again, whereas among the Kiranti people (Rais and Limbus) the traditional system of land tenure - *kipat* - meant that a clan or sub-clan would have had exclusive rights over a specific area of land, the change of the law on land rights, the inflow of migrants over the last century and a half and the rising population have resulted today in a complicated pattern of land rights (or usage, as many are not formally recognised) where a household's grazing area, forest resource or water source may be in different Village Panchayats and, in some cases, may be used in association with different groups of other households.

The situation is complicated further by the fact that most of the forest/scrub/grassland areas are legally the responsibility of the Forest Department, (see Land Tenure), following the nationalisation of forest and adjacent grassland. In the Southern Zone of the Arun Basin there is, as a consequence, uncertainty over the situation of some 50% of the land area. Thus there is an urgent need to define the present position. Such an adjudication of rights would identify areas which are properly in private ownership and those that must be retained as national forest. A much more vital and sensitive situation will arise with regard to areas which are legally Government land but in practice have continued to be used by households with traditional rights to them - and probably by others also. Particularly for the households with little cultivated land, such resources are vital for their survival. Improved environmental management of these areas requires that

rights to specific resources by defined groups of households are recognised. Two aspects of such recognition, however, have to be appreciated. One is the scale of the operation involved: the areas in any particular instance may be quite small - perhaps as little as 5-10 ha - so that the number of parcels would run perhaps into several thousand per District. Of greater concern is the possibility that any registration of rights, particularly if they were to be made permanent, would be abused by the elites to take rights for themselves which properly belong to households with little influence and for whom the loss would mean destitution. The two problems might be overcome through the current exercise to identify households living below the absolute poverty level (see section on Basic Needs Directives): this is due to lead on to the identification of projects to assist them. Such projects could include the allocation, to groups of households, of forest, grassland or other resources which would be made available to them on lease, the terms of which would have to be carefully defined. In the case of forestry, they would have to be compatible with the rules for Panchayat Forest and Panchayat Protected Forest. Whilst these details were being defined the extraction of products could be limited to those required for the individual household's own use and not for sale. Such an arrangement would also obviate the need for exact demarcation, unless it became a matter of dispute. It will clearly take a considerable time before management plans for these parcels of forest, scrub or grazing land are prepared in a joint exercise between the beneficiaries and the appropriate technical staff. Nevertheless, the acceptance of a group's rights over a particular area for a defined, and extendable, period of time, is the first major step in improved environmental management of those resources whose control will lie with groups rather than individual households.

It is sometimes stated that, because of their upbringing in isolated homesteads rather than in villages, the people of the Arun Basin - and Eastern Nepal generally - are less responsive to the idea of communal cooperation than people in other parts of the Kingdom. This may be relatively so, but there are examples of successful cooperation. Cronin (1979) recorded the case of the controlled use, by common agreement, of the forest resources of Dahbaley, 1 980 m, in the Arun Valley. Howarth and Pant (1987) describe the successful management of an irrigation scheme in Dingla, Bhojpur.

Again, the overall condition of the forest resource in the Arun Basin indicates that, while it is not being actively managed to obtain a sustainable yield, nor is it being wantonly destroyed, as is often said to have been the consequence of forest nationalisation. It is reasonable therefore to argue that a major explanation for this is that traditional rights continue to be accepted at the local level.

It is a truism that the most effective encouragement for community projects is acquaintance with an existing successful enterprise. Nevertheless, where projects are being initiated with groups that have not previously shown cohesiveness and cooperation in any enterprise, it will be particularly important to identify each household that is expected to participate and ensure that all are involved at every stage from the initial proposition onwards. In such circumstances, KHARDEP also found that it can be valuable to undertake Action Studies, where someone is assigned to the project as a catalyser and facilitator. The task is to guide the beneficiaries in their planning and work programming and assist them in their contacts with technical departments, banks and markets. (see, for example, Pant 1985). The period such a person stays with a project will vary with the circumstances but it should be anticipated that the

incumbent should live in the area for the first year.

The encouragement of beneficiary or user groups in the Arun Basin, as in other mountain areas of Nepal, is one of the main means whereby sound environmental management with sustainable production may be achieved. At this stage, the scale of the operation required taxes the imagination and its successful implementation with social equity is so formidable that it is not possible to be confident of the outcome, but there is an undoubted need to attempt it.

Woman - The Neglected Familiar

In the Arun Basin, as in the rest of rural Nepal, women are the major decision makers and workers in the farming systems. It is they also who mainly collect water, fodder and fuel and are thus the people principally involved in the conservation of these resources. This role of women in environmental management has received inadequate consideration in the planning and implementation of development programmes and projects.

Acharya and Bennett (1981), in their aggregate analysis and summary of eight village studies into the

TABLE 18: TIME USE BY MEN AND WOMEN (AGE 15 +); HOURS PER DAY BETWEEN 0400 AND 2000

ACTIVITY	Mean of 6 Villages		Pangma	
	Male	Female	Male	Female
A. Conventional Economic				
Animal Husbandry	1.43	0.97	2.08	0.90
Agriculture	2.73	2.74	3.93	3.57
Manufacturing	0.42	0.45	0.23	0.19
Outside income earning (In village)	1.24	0.46	0.16	0.33
B. Expanded economic				
Hunting and Gathering	0.17	0.05	0.24	0.10
Fuel Collection	0.24	0.38	0.28	0.35
Water Collection	0.07	0.67	0.10	1.12
Household Construction	0.25	0.08	0.35	0.07
Food Processing	0.18	0.97	0.14	1.56
C. Domestic	0.79	4.03	0.86	4.19
D. Leisure / social maintenance / education	8.48	5.20	7.63	3.62

Source: Acharya & Bennett (1981)

TABLE 19: THE RESPECTIVE CONTRIBUTION (%) BY MEN AND WOMEN TO HOUSEHOLD INCOME: PANGMA, SANKHUWASABHA

Source	Sex and age ->		Sex and age ->	
	Male 15 +	Female 15 +	Male 10-14	Female 10-14
Animal Husbandry	3.18	1.76	0.71	0.37
Agriculture	22.96	26.66	0.87	1.41
Hunting and Gathering	2.35	2.62	0.15	0.25
Manufacturing*	0.77	0.71	0.01	-
Food Processing	1.86	23.54	0.33	0.67
Wage and Salary	3.99	4.54	-	-
Trading	0.06	0.23	-	-
	35.17	60.06	2.07	2.70

* E.g. weaving, basketry, pottery

status of rural women in Nepal, demonstrated that, in addition to their domestic duties, women's work on conventional economic activities is almost as great (80%) as that of men and, in expanded economic activities, is substantially greater. One of the eight village studies was undertaken in Pangma Village Panchayat, Sankhuwasabha. The time use data recorded in these studies shows clearly the overall heavy work burden of women including their input, in terms of time spent, on economic activities, relative to men - TABLE 18 summarises the data for the studies as a whole and for Pangma.

Again, the contribution of women to the household income, even without imputed wage rates for domestic work (but including value-added calculations for items such as processed food and goods produced at home), was shown to be greater than that of men - 49.5% compared with 44.9% for men - the balance coming from the children. The figures for the 24 households of Lohorung Rai in Pangma were even more remarkable - TABLE 19.

Thirdly, women make a number of the major managerial decisions during the farming year. The main cropping patterns are usually well established, following a traditional system, but the selection of the grain for seed at harvest, its drying and storage are largely done by

women. They also are responsible for the vegetable garden. Particularly on rainfed land, fertilisation is predominantly organic for which the women are responsible. Women also play a major role in the rearing of livestock. Furthermore, an appreciable number of households are headed by women, perhaps in the region of 15%.

Planned development of natural resources in the Arun Basin began on an appreciable scale with the initiation of the HMG/ODA Koshi Hill Area Rural Development Programme (KHARDEP). This initially included no specific projects for women: this was due partly to a belief that such projects would be unacceptable for social and cultural reasons, particularly among the Indo-Aryan groups, and partly because it was felt that women's needs could be more effectively met through the overall development programme. In practice, however, this meant that women would participate only as adjuncts to their menfolk.

As KHARDEP was implemented, it quickly became apparent that women were not benefitting from its activities either directly or indirectly. It was decided that a special focus on their needs was justified and that this could best be achieved through the Women's Training Centre (WTC) in Dhankuta.

The WTC had been established in 1975 and, in 1980, when a complementary extension service was established nationally through the setting-up of the Women's Development Section within the Ministry of Panchayat and Local Development, the Centre took on an extension role as well as that of training. The experience of the Centre over the years since 1980 has demonstrated both the capabilities and limitations of a special women's programme.

The WTC was able to demonstrate that rural women were willing and capable of taking short training courses if they were run during the dry season, when farm work was relatively light. The success of such courses depends on the trainees being selected from among women who understand what is involved and are keen to gain the advantages of the training. Such training covered functional literacy, health education, sanitation, Panchayat (current affairs) and food preservation. Training in agriculture and skill development was handicapped by limitations of staff and facilities. One of the major benefits of these courses lay in the development of the trainees self-confidence and self-esteem, which is generally recognised as an important factor in increasing women's ability and determination to participate in community affairs.

Experience with the courses also showed the futility of teaching women about the nutrition of children without devising means of relieving the poverty which prevented them from practising it (Nepal 1988) or of training in health education involving fairly substantial use of water when, at some times of the year, water might have to be brought from an unclean source some hours walk away. Again, any new income-generating techniques must take account of a woman's existing work load and commitments.

Assisting women to become improved environmental managers is a complex matter whether the approach is through new farming practices, through income generation utilising non-agricultural land, e.g. *allo* cloth production from yarn extracted from *Girardinia diversifolia* (see below), bamboo products, silk production or beekeeping, or through relieving the pressure on the environment through income-generation from other sources, e.g. cotton inlay (dhaka) weaving (Dunsmore S 1983) or integrated tourism. Any

intervention must take account of the whole range of the rural women's activities and be specific to the circumstances of the individuals or group concerned.

The WTC/KHARDEP approach to extension appreciated this and also the fact that many women would be unable to leave home for two to three month courses. Women's Development modules were therefore established in five Agricultural Service Centres, each serving a number of Village Panchayats. A module was staffed by Women Extension Workers and (local) Women Volunteers who had been trained at the WTC. The intention was that each Volunteer would assemble a group of 15-20 women in her area and run evening functional literacy courses for the group over a period of three months. Subsequently, the Volunteer, having become known to the members of the group, would make home visits to each, gather information about their circumstances and thus, through discussions with them, devise appropriate projects for each group. In the event, for reasons which included the dispersed nature of the farms in the area and difficulties in arranging adequate supervision and guidance to the field staff, few adult, married women joined the groups and the approach was therefore unsuccessful.

In 1981, a number of women from some of the most remote and impoverished villages in the Basin sought help from KHARDEP in the development of products from the fibre of the naturally occurring giant nettle, *allo* (*Girardinia diversifolia*), as a means of income generation. The assistance they required included advice on product development and marketing, together with a limited amount of material support. The result has been the development of two new forms of cloth, one similar to linen and one, *allo/wool*, a form of tweed. The market for the products seems to be most promising (Dunsmore S 1985). This development will have the threefold advantages of (a) direct conservation through the careful management of the nettle areas, (b) the increase of the household's income, thus enabling it to buy in food and thereby (c) reducing the level of exploitation of already impoverished farms. Following the initial KHARDEP response to the specific requests concerning *allo*, the WTC were able to discuss with the weavers the desirability of a number of them undertaking a training course at the Centre. The need for functional literacy for recordkeeping etc was readily appreciated

and the value of other aspects of the training understood. In the event, a group, with a range of ages, went from this remote area to Dhankuta for the course, did well and enjoyed it. Four of their number were trained as Women Volunteers. They were natural leaders who were later elected by the weavers on to their committee. They could well have become the catalysts for activities in other fields if the women's extension programme had not terminated in 1985 with the ending of ODA financing.

In 1980, Pakhribas Agricultural Centre introduced an extension programme on vegetable growing techniques to farmers in the Village Panchayats near the Centre. This made little progress while the approach was made to men but, when, in 1986, the emphasis was switched to women - the actual vegetable growers - the response was remarkable, with the number of gardens rising from 75 to 210, totalling 65 ha (PAC 1987).

Pakhribas's experience with their Women's Participation Programme, as elsewhere in the Arun Basin, tends to confirm the view of Acharya and Bennett (1983) that women of the Tibeto-Burman communities, with their greater freedom of action and their participation in the market economy, are more immediately responsive to extension proposals than women of the Indo-Aryan groups.

Experience in the Arun Basin has demonstrated that a separate multi-sectoral women's programme is neither practical nor desirable and also that it is unrealistic to expect an overall development programme to meet the needs of women - and thus be fully effective - without gender-specific components.

In considering means whereby more effective environmental management in the Arun Basin might be achieved through increased support to women, the following constraints must be taken into account.

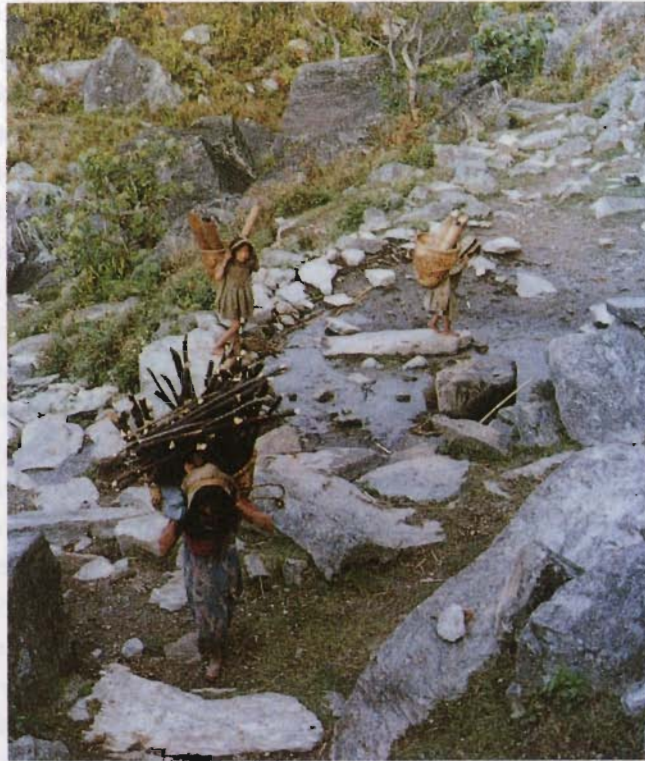
1. For the foreseeable future, HMGN has decided, as a matter of policy in the light of the economic circumstances of the country, not to expand the Government service. The establishment of a parallel women's service in the technical departments is not feasible for that reason. It is doubtful if such an approach would be successful anyway: there is the probability that it would never develop into

anything more than an ineffectual token programme.

2. The numbers of women trained, or available for training, in the natural resource disciplines - and indeed others - are very limited. The current national literacy rate for women is 12%. In 1985, the total number of students, nationally, at all levels in agriculture and animal science were respectively 1 163 and 13 for men and women. In forest science, there were 317 men and 16 women. In the same year, the number of trained women in the agricultural sector was 26 at the sub-professional Junior Technician / Junior Technical Assistant level, compared with 2 074 men, and 180 at Agricultural Assistant level, compared with 3 170 men. In cooperatives, there were 107 women and 4 625 men (WSSC 1986). There is thus no realistic prospect of a substantial proportion of women serving in the natural resource agencies for some years to come. Furthermore, of those available, a high proportion would come from the Kathmandu valley or the *terai* and find service in the mountains very difficult.
3. There is a general lack of appreciation of the remarkable skills of rural women, developed from childhood, in the wide range of activities which they undertake. Thus it has been stated that " the women of Nepal have not been able to fully take part in the development activities because of their uneducation, ignorance and poverty. The superstitions prevalent in the society and negative thinking have been major obstacles in mobilising women to participate..... Since the literacy rate of women is still 12% only, the majority of women are ignorant and uneducated." (NPC 1986). It is essential that the abilities of rural women should be appreciated by all those working in development and that the women should be seen as major partners participating in all stages of projects.

The means whereby support can be given to women to enable them to improve their effectiveness in the field of environmental management will therefore require five components.

1. Introducing appropriate gender activities into the programmes of the sectoral agencies, particularly



9.

PLATES 9 & 10: THE ROLES OF WOMEN

Women's input to farming equals or exceeds that of men: in addition their household duties involve physically tiring and time-consuming work

- 9. Collection of firewood and water
- 10. Milling grain



10.

the Departments of Agriculture, Livestock Development and Animal Health, and Forest (Community forestry). The WTC could have a role in this by introducing the concept, and means of implementing it, to District Panchayat and Village Panchayat members and to technical staff, through workshops, field days and talks.

2. Continuation of functional literacy and related training by the WTC for their practical benefits, as a confidence building activity and as a means of encouraging women's groups to discuss their situation as they see it. Agricultural and other extension programmes have often failed in the past because they have involved an attempt to gain the adoption of pre-planned activities which have not been seen by the intended beneficiaries as sufficiently relevant to their needs. The WTC's extension programme in the Arun Basin has not so far been successful because of the inappropriateness of the initial stage of functional literacy training (see above); nevertheless, the basic approach of identifying a potential leader from the particular community, giving her training at the WTC and subsequently supporting her in a catalytic role with her group of rural women in the identification of appropriate activities and subsequently as intermediary or support in any approach to the relevant sectoral agency or the Panchayat, is sound.
3. Reducing the current workload of women. Much of this work load is unnecessarily time-consuming and physically exhausting. This comment applies particularly to aspects of food processing - rice hulling, grain grinding - and the collection of water, fuel and fodder. Mention has been made earlier of the negligible use of water mills in the Arun Basin: increasing the numbers of these for grinding and milling would substantially reduce the workload.

Instances are known where women have to spend up to 4-6 hours on journeys to collect water during the dry season. In other communities, the collection of fuel and fodder may be similarly demanding because of the distance or paucity of the available resources. The identification of such needs should be part of the Panchayat planning process when deciding priority areas for drinking water supply

schemes and community and private forestry projects.

4. Over time, the proportion of women in the technical services should increase and it is important that among the field staff in daily contact with the rural women there should be a preponderance of women from a similar background. Because of the limited number of girls from the mountain areas completing secondary education - and thus qualifying to go on for technical training - this has been difficult until recently. To overcome this problem, a residential Agricultural Technical School (ATS) was established at Uttarpani, near Dhankuta, for children from farming families in the Koshi hill districts, who have completed seven years of schooling. At the ATS, these students follow a four year course leading to the award of a Craftsman Certificate of Technical Secondary School Level - a qualification accepted by the Departments of Agriculture and of Livestock Development and Animal Health for appointment as Junior Technical Assistants: it would be equally suitable for staff of cooperatives and the Small Farmer Development Programme of the Agricultural Development Bank. A similar approach would be possible for community forestry training. Opportunities will be offered to continue with more advanced training after several years field service. The first course at the ATS started in 1984 and women students have been included in each of the five annual intakes (1984-1988).
5. Income generating projects. In terms of environmental management, income generating projects may have direct or indirect benefits. Direct benefits result from projects, such as small livestock enterprises, where improved management of natural resources - production or conservation of fodder, improved compost making, stall feeding in preference to extensive grazing - is a component of the activity or where the conservation of the exploited resource, e.g. bamboo or allo, is encouraged because of its importance in sustaining the enterprise. Other income generating projects, which do not involve the use of natural resources, e.g. inlay cotton (dhaka) weaving using purchased cotton yarn, or integrated tourism, reduce the need

for the household to over-exploit their farm land.

The most successful income-generating projects for women in the Koshi hills in recent years have involved the development of wider markets for the products of their traditional skills e.g. *allo* cloth, embroidered items, bamboo and pine needle products. These have also mainly involved the use of locally available or inexpensive materials. This contrasts with the experience elsewhere in the Kingdom where the Production Credit for Rural Women Programme operates and where 80% of the projects have involved livestock and very little has been done with cottage industries (Baer 1988). The two types of project are not mutually exclusive and it would be useful to monitor the progress of each type.

All these activities in support of women should be beneficial not only in environmental and economic terms and in the raising of the status of women in the community but also enable the women to undertake more effectively what, to many, remains the most cherished role of raising the family.

CONSERVATION

Southern Zone

To date there has been almost no active conservation in the Arun Basin, other than that resulting incidentally from projects whose principal objective was something more specific, e.g. afforestation, road construction. The Soil Conservation Research, Demonstration and Training Centre was established at Chatra, to the south of the Arun Basin in 1957 to undertake studies in the Eastern Himalayas (Sachdeva *et al* 1986) and, over the years, there have been several other proposals for soil and water conservation projects in the Basin but little resulted from any of these initiatives. KHARDEP Phase 2 did not include any specific conservation activities.

In 1984, the Department of Soil Conservation and Watershed Management prepared a preliminary watershed management plan for Dhankuta Town Panchayat and three adjacent Village Panchayats (Shrestha & Sthapit 1984): detailed plans are being drawn up for this area in 1988. This should offer the basis for the first cross-sectoral, coordinated approach to

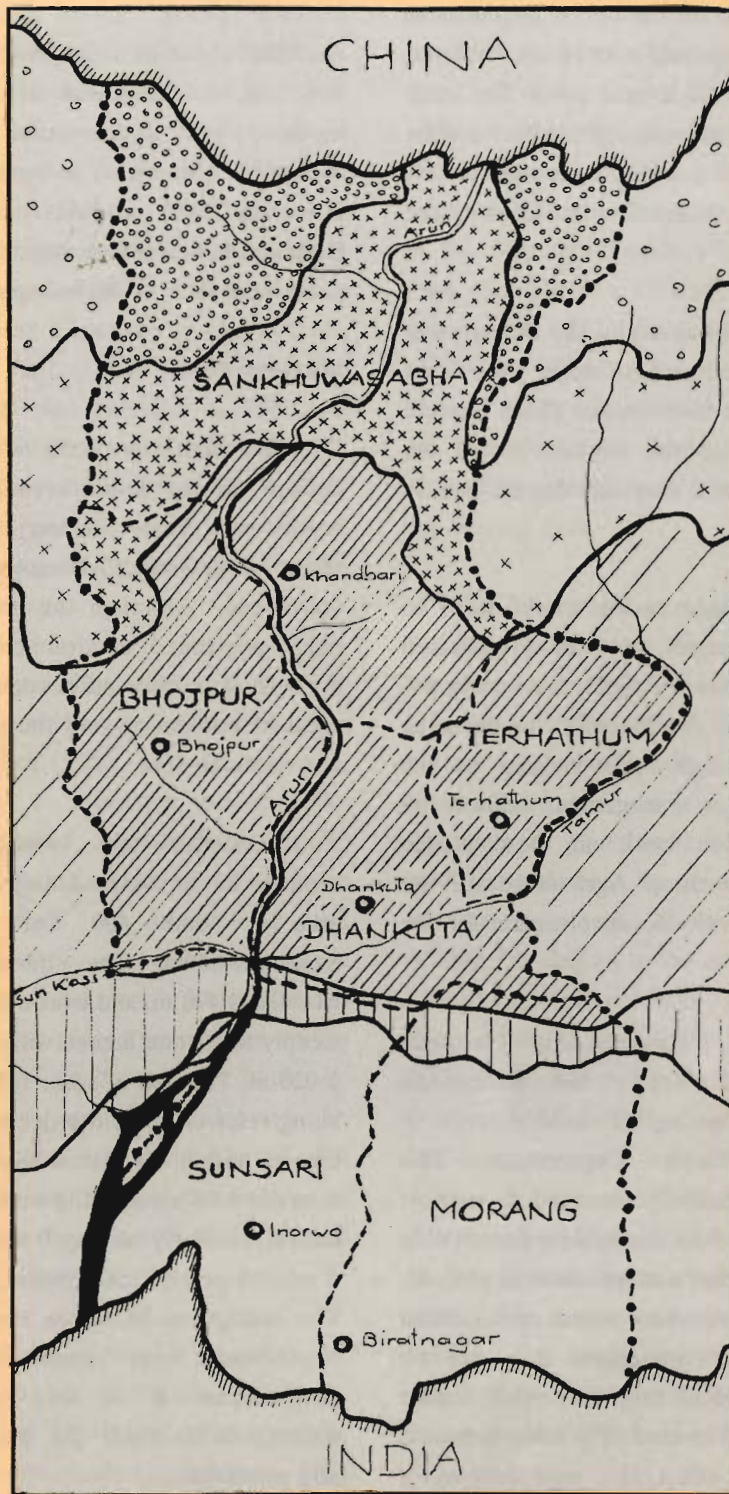
conservation and will be an important step in environmental management. It will take place though in an area where land use is already well-established and where no major changes will be practicable. In the Town Panchayat, the demand for building sites to meet Dhankuta's role as Regional Headquarters has already led to the use of plots which present serious problems for stability. In the three Village Panchayats, 53.5% of the area is cultivated land, with a multitude of owners farming parcels of land of usually under 0.25 ha. Nevertheless, immediate steps can be taken in the two subcatchments concerned to introduce the concept of landscape control of run-off from arable areas and rehabilitation/preventive structures in the main water courses.

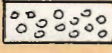
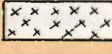



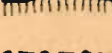


If the programme for the four Dhankuta Panchayats is carefully planned and sensitively implemented, it should serve as a model which will make the introduction of similar programmes elsewhere in the Basin much easier. Meanwhile, a great deal can be done on a single sector basis.

The major agencies whose activities include a conservation component are the Forest Department, the Department of Agriculture, the Department of Livestock Development and Animal Health, the Department of Drinking Water and Sewerage, the Department of Irrigation and the District Panchayat/District Technical Office. The conservation component - preventive, rehabilitative and extension - could be much increased.

The most basic factor in establishing sustainable farming systems, and thus sound environmental management in the Arun Basin, is the management of the forest resource. In the account of the farming systems, the importance of the various forest products was emphasised. In spite of the development of the national electricity grid, including the Arun-3 hydro-electric scheme, and possibly other schemes to encourage the use of alternative fuels to firewood, it must be anticipated that the effect on the use of fuelwood in the Arun Basin will be confined to the urban centres. It is unrealistic to expect any substantial reduction in the demand for fuelwood in the rural areas over the next generation. The needs of the people and of conservation thus both emphasise the vital place of forestry - community and private. This is considered

TEXT MAP 7
 PHYSIOGRAPHIC DIVISIONS OF THE
 KOSHI ZONE



-  High Himalaya
-  High Mountain
-  Middle Mountain
-  Siwalik
-  Tarai
-  International Boundary
-  Koshi Zone Boundary
-  District Boundary

further in the Section on User Groups. In regard to this aspect, there is a further need for the Forest Department to identify those areas that it would wish to see declared national protection forests or wilderness areas. The latter could include areas in the north-east of Sankhuwasabha (Milke Danda); where unique habitats for a wide variety of Nepalese rhododendrons, Magnolias and orchids are found (Shrestha 1988).

It is, similarly, the responsibility of the Department to identify areas of medicinal and aromatic plants and prepare management plans for them. These should combine sustainable use with the exploitation of the resource by the households who currently depend heavily upon them.

Reference has been made earlier to the need to introduce conservation measures on rainfed cultivated terraces to reduce the loss of soil and nutrients. Attention was also drawn to the potential for reducing environmental damage through improvements to the conveyance systems and water management methods on irrigation schemes. Extension work on these is the responsibility of the Department of Agriculture and the Department of Irrigation with the involvement of the District Technical Office.

In recent years, the Department of Livestock Development and Animal Health has undertaken extension work on the planting of fodder trees in association with the Forest Department. This cooperation could now be usefully extended to support silvo-pastoral projects linked to community forestry. In addition, for both conservation and production reasons, there is a pressing need to introduce sound management of the areas of grassland/Eupatorium that will be retained for grazing. Linked to this, and other fodder producing projects, is a need to control grazing livestock, which currently adversely affect the regeneration of forest and cause accelerated erosion.

Irrigation projects, drinking water supply schemes and trails can be the cause of serious environmental damage, if they are not well designed and managed. Most of the new schemes are now the responsibility of the District Panchayat. It will be necessary for that body to make the often politically difficult decision to relate the scale of their programme to the capacity of their

technical staff (see also Prioritisation).

The above review considers conservation activities that can be undertaken at District levels. There are aspects of conservation within environmental management that have to be undertaken on a wider scale than this. An obvious example of this is the Dharan-Dhankuta-Basantapur road: these aspects will be considered later in discussing sub-regional activities.

Northern Zone

The Northern Zone of the Arun River Basin - defined as the areas between 27°33' North and the border with Tibet (Xizang) - comprises areas of High Himalaya and High Mountain, much of it a very fragile ecosystem. Although the greater part of the Zone is lightly populated, environmental management must take account of conservation requirements, the needs of the resident population and the growing impact of trekkers and mountaineers.

In recent years, considerable interest has been aroused in the Barun-Mangrwa (or Saldima) watershed area - some 400 km² in the north-west of Sankhuwasabha. The Barun originates on Mount Makalu, 8 470 m, and over a distance of some 22 km falls steeply to its confluence with the Arun, at an altitude of 1 020 m. This fall of some 6 000 m has led to the Barun being referred to as the deepest valley in the world. The climate within the Barun basin ranges from sub-tropical to arctic with a vegetative cover, between 1 000 and 4 000 metres, similarly varying from sub-tropical to alpine and a related precipitation pattern from 4 000 to 1 000 mm. The contiguous Mangrwa river rises in Tibet and flows North-South over some 16 km through an arid environment: it is thus possible within the two watersheds to study the inter-relationships of altitude and precipitation.

There are no permanent human settlements in the area but the high pastures are used for summer grazing. Reference has been made earlier to the environmental damage being caused at higher altitudes by mountaineering expeditions and at lower altitudes by the felling of primary forest for slash and burn agriculture. Nevertheless, most of the area remains pristine and probably unique in its biological diversity. It has been

referred to as "a microcosm of the climatic diversity in the Hindu Kush Himalaya..... having a greater diversity of mammal species than any other Himalayan geo-biological system" (Taylor-Ide and Shrestha 1985) and as having a wealth of bio-physical diversity of potentially global significance (Woodlands Mountain Institute 1988). Taylor-Ide and Shrestha (1985) proposed that the area be declared a National Park. Subsequently it was decided that the area might be included in an extension of the Sagarmatha (Everest) National Park. The Sagarmatha National Park, 1 148 km², lies to the west of Sankhuwasabha. It was gazetted in 1976 and declared a World Heritage Site by HMGN under the 1972 UNESCO World Heritage Convention. The entire area of the Park lies above 3 000 m and one of the objectives of extending it would be to support the ecosystem by the extension of the altitudinal range.

National Parks are intended to serve as a reservoir of genetic resources, protect watersheds and offer facilities for scientific studies (MFSC 1988). In this case, the extension would protect an important section of the watershed above the proposed Arun-3 hydro-electric scheme. It is appreciated that such Parks can only be successful if their objectives are understood and supported by the people living in, or currently using, the area of the Park. Elsewhere, local people have regarded Parks as a form of restriction placed upon them to the detriment of their wellbeing. Thus any attempt to change existing activities, because they are incompatible with the objectives of the Park, must be compensated with alternatives. Indeed the development of the Park must include a component to raise the standard of living of all people affected by its establishment.

Mount Makalu is already a popular objective for mountaineers. It can also be anticipated that the numbers of trekkers visiting Sankhuwasabha, currently quite small, will rise, particularly following the completion of the road to Num. Nepal has learned that, while the income generation and job creation that results from this form of tourism is welcome, it has to be carefully planned to avoid adverse environmental consequences - over-exploitation of the fuelwood resource, unplanned development of houses and teashops, inadequate arrangements for sanitation and litter disposal.

These varied factors that have to be considered in establishing a National Park are appreciated: thus it is intended to have a two year planning phase for the extension of the Sagarmatha National Park which would consider four aspects - park management, community development, tourism development and scientific research. The area to be covered will also be defined but in the west the boundary will be the existing National Park (Solukhumbu District): to the north it will run to the border with Tibet and to the east as far as the confluence of the Arun and the Barun. It is hoped to include as much lowland habitat to the south as is possible without interfering with human settlements. The area of the extension is likely to be greater than that of the existing Park.

Environmental management in the north-east of Sankhuwasabha must take account of the needs of the transhumant herdsman to whom reference was made in the section on Livestock. The dearth of information on current stock numbers and practices makes it imperative to undertake a survey before any environmental management plan could be formulated. Such a survey would complement the study on the proposed extension of the Sagarmatha National Park. It should cover all Village Panchayats to the east of the Arun as far south as Diding together with Hatiya, Kimathanka and Pathibara, if these are not included in the Sagarmatha study. Of the Village Panchayats covered by such a survey, three will be directly affected by the Arun-3 hydro-electric scheme and its access road: they are Diding, Num and Pathibara. Others, to the north of Num - Hatiya, Kimathanka, Chepuwa and Pawa Khola - comprise an important part of the drainage basin above the Arun-3 dam. Shrestha (1988) has drawn attention in particular to the area between the bridge below Num and Chepuwa village, which " may be considered as a "hot spot"". He recommended the immediate prohibition of slash and burn activities and an active programme of hill stabilisation, particularly through afforestation. The prohibition of slash and burn agriculture could only be introduced when alternative forms of crop production or income generation were made available, but the strength of the plea for prohibition underlines the importance of an early initiation of a study of the area.

ZONAL ACTIVITIES

The Decentralisation Act and Rules have defined the role of the District Panchayat in development planning and implementation and thus a major aspect of Government's role in environmental management. The argument for this approach is persuasive and the earlier sections of this chapter have suggested how it could be further developed from the present position in the Arun Basin.

In reviewing the Arun-3 hydropower scheme (q.v.), it was suggested that a number of activities could be more effectively undertaken at the Zonal rather than District level: these were -

- a. Environmental monitoring
- b. The supervision of small - scale industrial development
- c. The improvement of agricultural marketing arrangements
- d. Support to the development of appropriate tourism
- e. Socio-economic studies on the impact of the Dharan - Dhankuta - Basantapur - Num road

To these activities should be added others including studies on more general aspects of socio-economic changes, traffic surveys and support to District planning, the cases for which can be briefly stated as follows:

Linked to the studies on the state of the natural resources should be others on the well-being of the people. An interesting approach to this was initiated by KHARDEP in the Impact Studies. Periodic data collection from representative households monitored the changes in their conditions, as a result of both natural circumstances and the effect of the various components of the development programme. A basket of indicators was used which included standard economic indicators together with indices of the nutritional status of both adults and children (Nabarro *et al* 1987). The Studies completed a five year survey in 1985. They justify a full review with the objective of identifying how, suitably amended, they should be continued. The review should also consider whether such Studies should be undertaken in the rural areas of the *terai* Districts.

Traffic surveys have been undertaken periodically in

the Koshi hills since 1979 and there is now a considerable body of information on the movement of people and goods within the area. There is currently no organisation that is responsible for assessing this data, continuing the surveys and using them for the planning of a communications network - roads, trails, bridges - within the area.

The lack of experience and shortage of trained staff at District level in the compilation and use of a comprehensive resource base and its utilisation in the preparation of a perspective plan has been mentioned earlier. The fundamental need for these for improved environmental management has been described. An area organisation could assist with this, through the short-term assignments of specialists and the organisation of workshops and seminars for both elected members and technical staff. This would complement, through increasing the range of specialisms and the numbers, the current work of the Regional Office of the National Planning Commission.

Thus the question arises of the desirability of establishing some development organisation between the District and National level. In considering this, it must be appreciated that there is no elected assembly at any intermediate level. Any organisation that is established must not diminish, therefore, the authority of the District and National Panchayats: its role must be to enhance the effective implementation of the Panchayats' programmes through technical support. This criterion is met by the activities listed above.

These activities would involve a substantial number of disciplines and people. Some of the studies might be required only once every decade, while others would be continuous, as the following examples illustrate:

- a. Monitoring of changes in forest cover and composition and in land use. Reference was made earlier (see sections on Vegetation and on Land Use) to the interpretation of panchromatic aerial photographs flown in 1978. This provides good base-line data for such monitoring. Given the rate of change of vegetative cover and the cost of undertaking such work, assessments at 10-year intervals would be appropriate. (If these could be carried out in the eighth year of each decade, it

would ensure that current data were available for the preparation of the Five Year Plan, starting at the beginning of the following decade.) Another aspect of such monitoring, whether aerial photography were used or satellite remote sensing such as SPOT employed, is that it might be more cost-effective to do it as part of a Regional programme.

- b. For the socio-economic studies of the type undertaken for the Impact Studies of KHARDEP, to which reference was made above, more frequent - perhaps five-yearly - data collection will be needed.
- c. Marketing studies would be undertaken as the need for them was identified.
- d. By contrast again, the Water and Energy Commission Secretariat programme for stream gauging will be continuous. So also will be the linked programme of measurement of total dissolved solids, which would allow an estimate of environmental changes occurring in the Basin to be made. Similarly, continuous measurements will be needed of suspended solid, which will be vital for the design of any additional hydropower units in the possible cascade of six, of which Arun-3 is the first. Again, the recording of rainfall and other climatic data by the Department of Hydrology and Meteorology is a continuing operation. It will probably involve additional stations, possibly including automatic weather stations to enable the higher, more isolated areas to be covered (The Department currently has five climatological stations and nine precipitation stations in the Arun River Basin, at altitudes between 142 and 2 591 metres, DIHM 1984).

Because of these varying requirements, it is neither necessary nor desirable that a Zonal organisation should have the capability to undertake all this work with its own staff. Much of the work would be undertaken by appropriate specialists commissioned by the Zonal organisation from Government Departments, Corporations, Tribhuvan University or private consultants. The principal task of the organisation would be seen as identifying the requirement, arranging for its commission and considering the implications of the findings in relation to develop planning and environmental monitoring.

The Koshi Zone is well suited to this approach both because it includes all five physiographic divisions, (TEXT MAP 7), which to a degree complement one another in development terms, and because the National Planning Commission and the major Departments each has a Regional Director based in the Zone (either in Biratnagar or Dhankuta). These Directors, or a senior representative, could form the core of the Zonal organisation together with representatives of the Water and Energy Commission Secretariat, the Department of Roads and the Nepal Electricity Authority. The Regional Director of the National Planning Commission would be an appropriate person as the chairman in view of the Commission's responsibility for longer term planning and evaluation and the need for the organisation to work closely with the Commission in Kathmandu. The Coordinator of the Koshi Hill Area Rural Development Programme would be most suitable as Member-Secretary.

In preparing detailed terms-of-reference for such an organisation the need for additional expertise on the permanent staff, for example, in the field of economics, will be identified. Nevertheless, a basic principle should be to keep the core staff to a minimum and ensure that the organisation has the flexibility to adapt to changing needs.

References

- Abell T M B (1981) Land use and forestry development in the Koshi hills of Eastern Nepal. London: Land Resources Development Centre KHARDEP report no. 25.
- Abernethy C L (1984) Report on a visit to Nepal April-May 1984. Wallingford (UK): Hydraulics Research Visit Report ODV. 174.
- Acharya M & Bennett L (1981) The rural women of Nepal. An aggregate analysis and summary of 8 village studies. Volume 2, Part 9 of The status of women in Nepal. Kathmandu: Centre for Economic Development and Administration. Tribhuvan University.
- Acharya M & Bennett L (1983) Women and the subsistence sector. Economic participation and household decision making in Nepal. Washington: World Bank Staff Working Paper 526.
- ADB (1987a) Hill fruit development project: final feasibility study report. Kathmandu: AFC/APROSC.
- ADB (1987b) National Land Use Planning Project. Kathmandu: Asian Development Bank/His Majesty's Government of Nepal, National Planning Commission.
- Aegerter S & Messerli P (1985) The impact of hydroelectric power plants on a mountain environment. Pages 98 - 129 in: Singh T V & Kaur J (editors) Integrated Mountain Development. New Delhi: Himalayan Books.
- Anonymous (1987) Report on first expedition to glaciers and glacier lakes in the Pum Qu (Arun) and Poi Qu (Bhote-Sun Kosi) river basins, Xizang (Tibet), People's Republic of China. Sino-Nepalese investigation of glacier lake outburst floods in the Himalaya. Lanzhou Institute of Glaciology and Geocryology of Academia Sinica; Water and Energy Commission, Nepal and Nepal Electricity Authority.
- Applegate G B & Gilmour D A (1987) Operational experiences in forest management in the hills of Nepal. Kathmandu; International Centre for Integrated Mountain Development Occasional Paper no.6.
- Baer, Dagmar (1988) Production Credit for Rural Women Project and its impact on the situation of rural women in Nepal. Kathmandu: International Centre for Integrated Mountain Development.
- Bajracharya D (1981) Implications of fuel and food needs for deforestation: an energy study in a hill village panchayat of Eastern Nepal. England: University of Sussex unpublished Ph.D thesis.
- Bannerji M L (1965) Contribution to the flora of East Nepal. Records of the Botanical Survey of India, 19, 2.
- Bilsen F (1987) Integrated tourism in Senegal; an alternative. Tourism Recreation Research, 13(1), 19-23.
- Bista D B (1980) People of Nepal. Kathmandu: Ratna Pustak Bhandar.
- Burbage M B (1982) Report on a visit to Nepal: the medicinal plant trade in the KHARDEP area - a study of development potential. London: Tropical Products Institute report no. R1033 (A).
- Caplan L (1974) A Himalayan people: Limbus of Nepal. in: Maloney C (editor). South Asia: seven community profiles. New York.
- Carson B (1985) Erosion and sedimentation processes in the Nepalese Himalaya. Kathmandu: International Centre for Integrated Mountain Development Occasional Paper no.1.
- Cassels C, Wijga A, Pant M & Nabarro D (1987) Results of the KHARDEP Impact Studies 1980-85: report on the household profiles; in-depth interviews with farmers in the Koshi hills, East Nepal. Liverpool: School of Tropical Medicine.
- Central Bureau of Statistics (CBS) (1985) National Sample Census of Agriculture 1981/82. HMGN

- National Planning Commission Secretariat, Central Bureau of Statistics.
- Central Bureau of Statistics (CBS) (1986) Statistical Pocket Book, Nepal. Kathmandu: National Planning Commission Secretariat.
- Conlin S & Falk A (1979) A study of the socio-economy of the Koshi hill area: guidelines for planning an integrated rural development programme. Koshi Hill Area Rural Development Programme report no.3.
- Cronin E W (1979) The Arun: a natural history of the world's deepest valley. Boston: Houghton Mifflin Co.
- Diemberger, Hildegard (1988) Personal communication. University of Vienna.
- DIHM (1984) Climatological records of Nepal 1981-82. Kathmandu: Ministry of Water Resources, Department of Irrigation, Hydrology and Meteorology.
- Dunsmore J R (1987) KHARDEP: rural development in the hills of Nepal. Land Resources Development Centre, Overseas Development Administration Land Resource Study 36.
- Dunsmore J R (1988) Rural development in the Koshi hills of Nepal: integration, coordination and interaction. Manchester Papers on Development, IV, 1, pages 123 -135.
- Dunsmore S (1983) Weaving in Nepal: dhaka topi cloth. London: British Museum Publications/Land Resources Development Centre.
- Dunsmore S (1985) The nettle in Nepal: a cottage industry. London: Land Resources Development Centre, Overseas Development Administration.
- Fürer-Haimendorf C von (1975) Himalayan Traders. London: John Murray.
- Gautam K H (1987) Legal authority of forest user groups. Banko Janakari 1.4,
- Goldsmith P F (1981) The land and soil resources of the KHARDEP area. Koshi Hill Area Rural Development Programme report no.16.
- Gowing J W (1985) End-of-assignment report by the irrigation adviser. KHARDEP report 186/85 Cambridge: Sir M MacDonald & Partners Ltd.
- Hagen T (1969) Report on the geological survey of Nepal. Vol.1 Preliminary reconnaissance. Denkschr. Schweiz. Neff. Geo. L XXXVI/1.
- Hildreth G (1986) Land Resource Mapping Project, Summary Report. Kathmandu: Kenting Earth Sciences Ltd.
- Hocking D, Mauch S & Zuercher D (1988) IHDP/LJRP (Nepal) Impact Status Report no. 1: for the period 1975-1987. Zuerich/Kathmandu: Interdisciplinary Research and Consulting Group for Infrastructure Planning, Environmental Quality and Natural Resource Management for the Swiss Development Corporation.
- Howard P F (1985) Factors influencing the nutritional status of children under five years old in Eastern Nepal - an analysis of data collected in Dhankuta in 1982-83. London: Overseas Development Administration Research Scheme R 3887: an interim report.
- Howarth S E & Pant M P (1987) Community managed irrigation in Eastern Nepal. Irrigation and Drainage Systems, 3, pp.219-229.
- Humphrey C (1980) Report on a field study in North Sankhuwasabha September - November 1979. Kathmandu: KHARDEP report no. 7.
- Ives J D (1986) Glacial lake outburst floods and risk engineering in the Himalaya. Kathmandu: International Centre for Integrated Mountain Development Occasional Paper no.5
- Jackson J K (1987) Manual of afforestation in Nepal. Kathmandu: Nepal-United Kingdom Forestry Research Project.
- Jeanrenaud J P (1987) Daphne L. Thymelaeaceae. Pages 242-246 in : Jackson J K - q.v.
- JICA (1985) Master Plan Study on the Kosi river water resources development. Japan International Cooperation Agency/ HMGN Ministry of Water Resources.
- JICA (1987) Final report of feasibility study on Arun-3 hydroelectric power development project. Japan International Cooperation Agency/HMGN Nepal Electricity Authority.
- Jones S F & Innes J B (1981) Agricultural Marketing Study Phase 2 (Dhankuta District), Volume 4.

- Agricultural marketing opportunities. Kathmandu: Koshi Hill Area Rural Development Programme report no.27.
- Kansakar D R (1988) Geology and geomorphology of the Arun River basin. Kathmandu. Report to the International Centre for Integrated Mountain Development.
- Kattelman R (1988) Personal communication. Center for Remote Sensing and Environmental Optics, University of California, Santa Barbara, USA.
- Kenting Earth Sciences Ltd (1987) Land Resources Mapping Project. Land Utilisation. Report and Mapping. Kathmandu: Kenting Earth Sciences.
- Khadka R B (1987) Study on the ecology of Barun valley with particular reference to mammalian fauna - a habitat analysis. Kathmandu: Tribhuvan University for Royal Nepal Academy of Science and Technology.
- Mahat T B S (1987) Forestry-Farming Linkages in the Mountains. Kathmandu: International Centre for Integrated Mountain Development Occasional Paper no.7.
- Mahat T B S, Griffin D M & Shepherd K R (1986) Human impacts on some forests of the middle hills of Nepal. Part I. Forestry in the context of the traditional resources of the state. *Mountain Research and Development* 6 (3), 223-232.
- MFSC (1988) Master Plan for the Forestry Sector, Nepal: main report. Kathmandu: HMG Ministry of Forests and Soil Conservation.
- Morris J & Gwyer G (1983) UK experience with identifying and implementing poverty-related aid projects. *Development Policy Review*, 1, 147-161.
- Nabarro D, Cassels C, Pant M & Wijga A (1987) The impact of integrated rural development: the Kosi Hill Area Rural Development Programme, East Nepal. Liverpool: School of Tropical Medicine.
- Nepal, Usha (1988) A field perspective of women's development in the eastern hills of Nepal. Kathmandu: Ministry of Supply, (manuscript).
- NPC (1986) The Seventh Plan (1985-1990). Kathmandu: His Majesty's Government of Nepal, National Planning Commission.
- NPC (1987) Programme for fulfilment of basic needs (1985-2000). Kathmandu: National Planning Commission.
- PAC (1987) Review of achievements 1972 - 1987. Dhankuta: Pakhribas Agricultural Centre.
- PAC (1988) Annual work programme (16 July 1988 - 15 July 1989). Dhankuta: Pakhribas Agricultural Centre.
- Pant M P (1985) Action research on community participation in the management of irrigation resources: a case study of Solma irrigation project of East Nepal. Report submitted to the Agricultural Development Council, Kathmandu.
- Rajbansi K G (1982) A general bibliography on fish and fisheries of Nepal. Kathmandu: Royal Nepal Academy.
- Ramsay W J H (1986) Erosion problems in Nepal Himalaya. In: Joshi S C (editor) *Nepal Himalaya, Geo-ecological perspectives*. Nainital: Himalayan Research Group.
- Regmi M C (1976) Land ownership in Nepal. Berkeley (USA): University of California Press
- Sachdeva C P, Ramasesha C S & Das D C (1986) Soil conservation in the Kosi Catchment. Government of India: Department of Agriculture and Cooperation.
- Schaffner U (1987) Road construction in the Nepal Himalaya: the Lamosangu-Jiri road project. Kathmandu: International Centre for Integrated Mountain Development Occasional Paper no. 8.
- SEADD (1986) Koshi hill area roads project. Bangkok: South East Asia Development Division, Overseas Development Administration (UK).
- Shah P B, Nakarmi G B, Duvadi A K, Tiwari K N, Shrestha B & Schreier H (1987) A resource evaluation of the Dhankuta district. Kathmandu: Department of Surveys, Integrated Survey Section.
- Sharma P (1988) Population dynamics and development linkages in the Arun watershed. Kathmandu: International Centre for Integrated Mountain Development.
- Shrestha B D, Ginneken P Van & Sthapit K M (1983) Watershed conditions of the districts of Nepal. Kathmandu: HMG/UNDP/FAO.

- Shrestha B D & Sthapit K M (1984) Watershed management plan for Dhankuta area (Belhara Village Panchayat, Dhankuta Town Panchayat, Bhirgaon Village Panchayat and Tankhuwa Village Panchayat). Kathmandu; Department of Soil Conservation and Watershed Management Field Document no. 20.
- Shrestha T B (1988) Development Ecology of the Arun River basin. Kathmandu: International Centre for Integrated Mountain Development.
- Shrestha T B, Dhungel S & Davis R (editors) (1985) Proceedings of the Makalu-Barun Nature Conservation Seminar.
- Sizeland P (1986) Notes on forestry in Sankhuwasabha. Khandbari: Forest Department (manuscript).
- Stainton J D A (1972) Forests of Nepal. London: John Murray (Publishers).
- Stapleton C M A (1987) Bamboos. Pages 199-214 in: Jackson J K - q.v.
- Stewart M (1987) A guide to the mapping of forest and land use types in the Koshi hills, Eastern Nepal. Surbiton: Land Resources Development Centre report number P-180.
- Stiller L F (1973) The rise of the house of Gorkha: a study in unification of Nepal 1768-1816. Manjuri, New Delhi.
- Taylor-Ide D & Shrestha T B (1985) The Makalu National Park, a proposal. Proceedings of the International Workshop on the management of national parks and protected areas in the Hindu Kush Himalaya. Kathmandu: King Mahendra Trust for Nature Conservation and the International Centre for Integrated Mountain Development.
- Tsuchida K (1983) Grassland vegetation and succession in eastern Nepal. Pages 47-87 in: Numata M (editor) Structure and dynamics of vegetation in eastern Nepal. Chiba University, Japan.
- WECS (1986) Land Use in Nepal. A summary of the Land Resource Mapping Project results. Kathmandu: HMGN Water and Energy Commission Report no. 4/2/310386/1/1.
- Woodlands Mountain Institute (1988) The extension of Sagarmatha National Park. Preliminary Project Paper. April 1988. Kathmandu.
- w SCC (1986) Statistics on women in Nepal. Kathmandu: Social Service National Coordination Council, Women Service Coordination Committee.
- Wyatt-Smith J (1982) The agricultural system in the hills of Nepal. The ratio of agricultural to forest land and the problem of animal fodder. Kathmandu: Agricultural Project Service Centre Occasional Paper no.1.

The Author

John Dunsmore served in Departments of Agriculture in Malaysia, first as an agronomist and later as head of the agricultural research branch of the State of Sarawak. In Sarawak, he developed his interest in the inter-disciplinary assessment of resources - agricultural, socio-economic and environmental - for agricultural and rural development planning. He continued with this work after joining the Land Resources Development Centre (LRDC) of the Overseas Development Administration (ODA) of the United Kingdom, firstly with a land resource study of the Belize valley, Belize, Central America and, subsequently, with a study of The Gambia, West Africa. Both of these led to the preparation of recommendations to the Government for agricultural development programmes. Later, he was involved with LRDC projects in a number of countries, particularly Indonesia, Malaysia, Bangladesh, the Yemen Arab Republic and Nigeria.

He first visited Nepal in 1978 in connection with UK assistance to the Koshi Hill Area Rural Development Programme, an involvement that continued until 1986 and included a period of two and a half years when he served in Nepal as Senior Technical Adviser to the Programme. In 1987 he was a member of the National Land Use Planning Project, Nepal and in 1988 participated in Phase 1 of the Natural Resources Management for Sustainable Development Study.

During 1988, he has spent several months as a member of the professional staff of ICIMOD in Kathmandu designing and coordinating the case study of the Arun River Basin which has led to this present report for publication in this ICIMOD Occasional Paper Series.

Founding of ICIMOD

ICIMOD is the first International Centre in the field of mountain area development. It was founded out of widespread recognition of the alarming environmental degradation of mountain habitats, and consequent increasing impoverishment of mountain communities. A coordinated and systematic effort on an international scale was deemed essential to design and implement more effective development responses in each of the countries concerned.

The establishment of the Centre is based upon an agreement between His Majesty's Government of Nepal and the United Nations Educational, Scientific and Cultural Organization (UNESCO) signed in 1981. The Centre was inaugurated by the Prime Minister of Nepal in December 1983, and began its professional activities in September 1984.

The Centre, located in Kathmandu, the capital of the Kingdom of Nepal, enjoys the status of an autonomous international organisation.

Participating Countries of the Hindu Kush-Himalaya region

- o Nepal
- o India
- o Bhutan
- o Bangladesh
- o China
- o Pakistan
- o Burma
- o Afghanistan

Director: Dr. K.C. Rosser

Deputy Director: Dr. R.P. Yadav

**INTERNATIONAL CENTRE FOR INTEGRATED
MOUNTAIN DEVELOPMENT (ICIMOD)**

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

Telephone: 525313, 521575, 522819
Facsimile: 977 1 524509

Telex: 2439 ICIMOD NP
Cable: ICIMOD NEPAL