Agricultural System

The agricultural resource base is severely limited due to the mountainous terrain and steep topography. The mainstay of livelihood remains a mixed farming system, which concentrates on subsistence crop production. The main crops are paddy, maize, millet, potato, and wheat. In the KHARDEP region, there is very little land suitable for cultivation which is already being used (Dunsmore 1987). Encroachment for more arable land is taking place in the northern region of the Arun Basin, where virgin forests, even at elevations below 2,000 m, are still encountered.

There are two basic cropping patterns: paddy-based for irrigated land, and maize-based for rainfed land. Livestock and forestry form an integral part of the farming system. Transhumance is practiced at altitudes beyond the upper limit of the cropping zone, i.e., 3,000 m. Below 3,000 m altitude, livestock is the principal source of draught power for ploughing croplands and for replenishment of soil nutrients. An average household with 5-7 people has an equal number of livestock associated with it. The average landholding is 0.5 ha per household. The ratio of cultivated land to forestland (inclusive of shrubland) is 1:2, as estimated from LRMP figures.

Citrus fruits, large cardamom, and potato are promising cash crops for the region. Tobacco, sugarcane, and oilseeds are produced primarily for home consumption. Small amounts are, however, sold in occasional marketing centres where traditional exchange of goods takes place.

Land - use Types

The area covered by field crops in the three districts of the Arun Basin amounts to 157,668 ha as per LRMP, and 70,240 ha as per DFAMS figures. The difference of 87,428 ha is so great that any attempt to justify any of the figures would lead to further confusion. The difference is greatest in the case of Bhojpur district, as compared to its sister districts, Sankhuwasabha and Dhankuta. (Table 6).

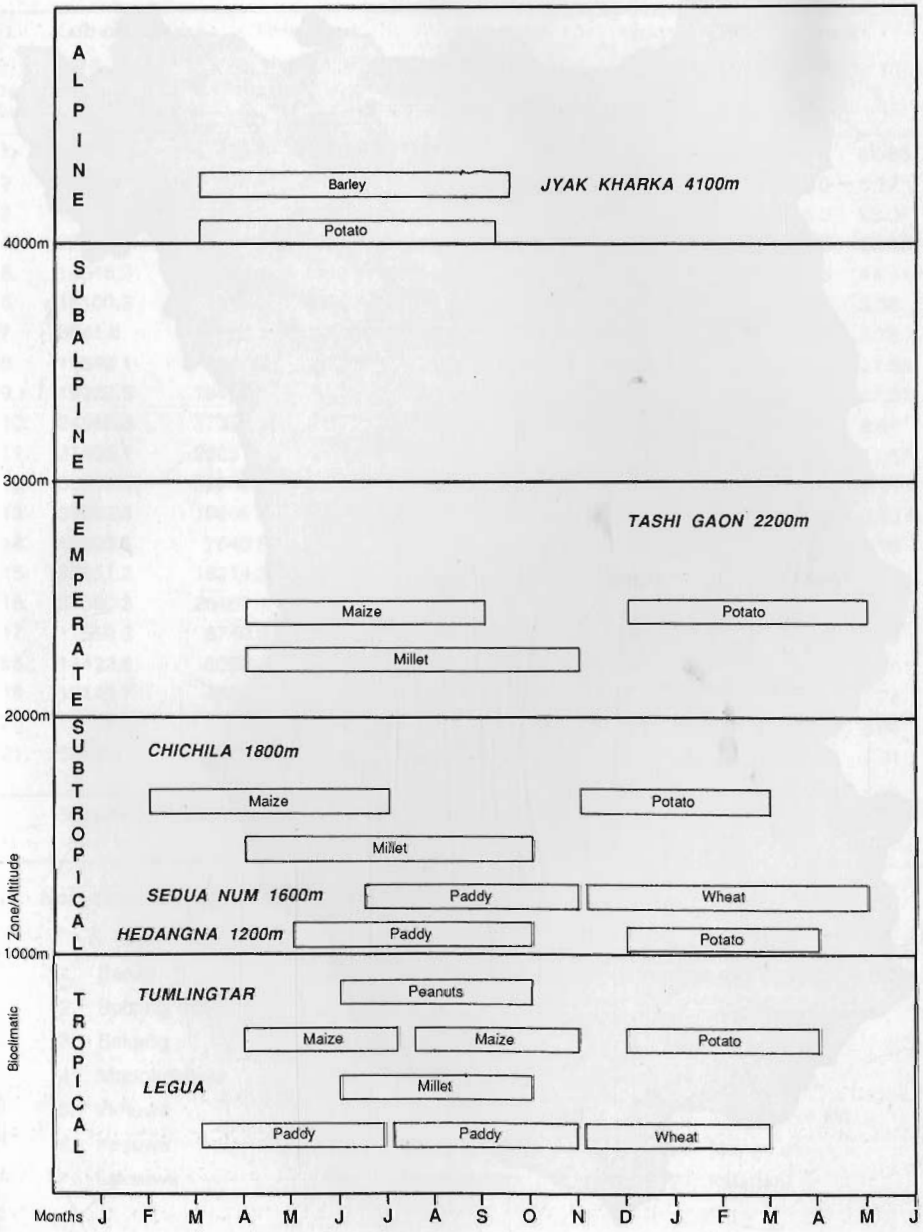
Table 6 : CROPPED AREA (in ha, 1978/79)

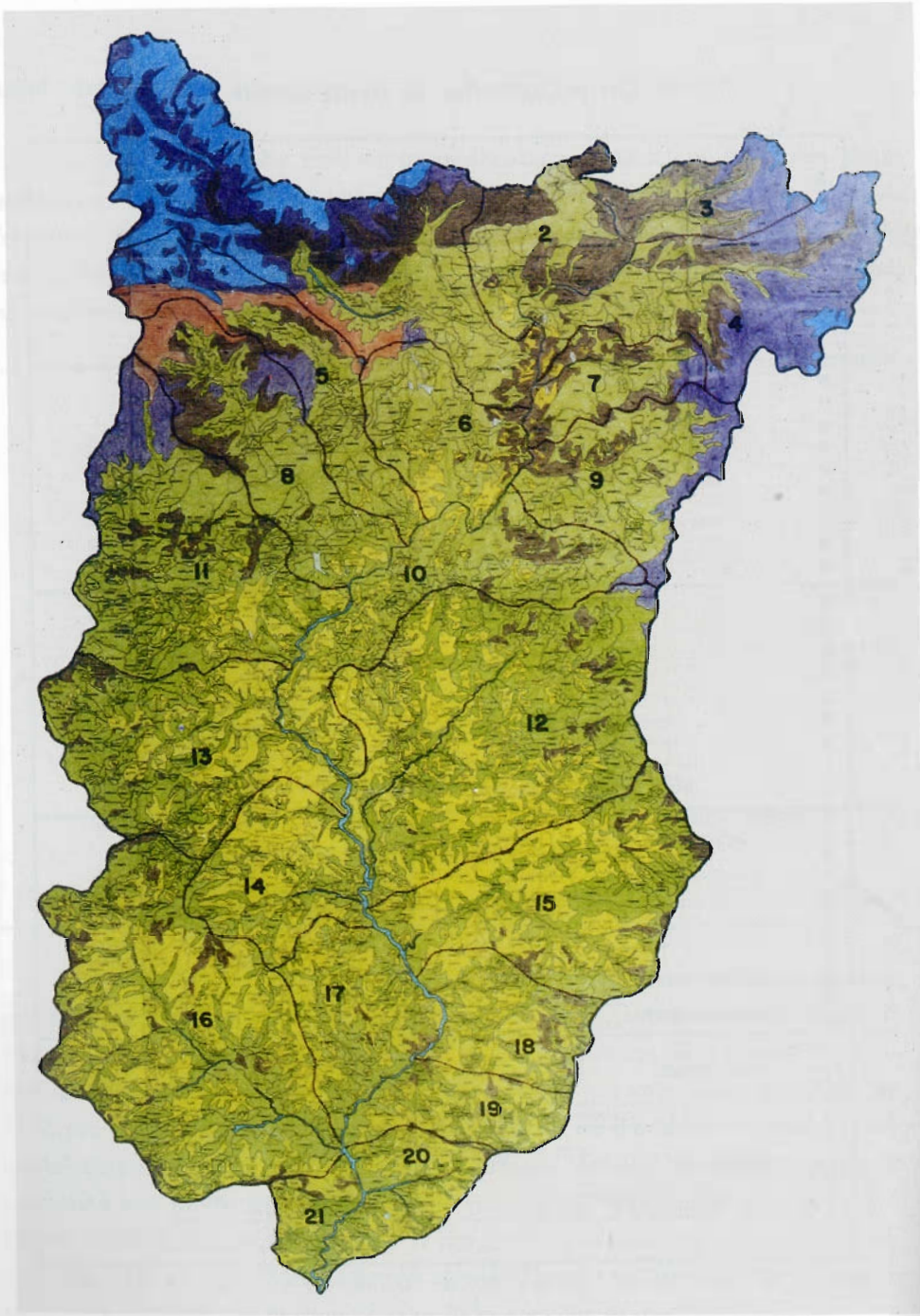
Districts	Source of Information		Difference
	LRMP	DFAMS	
Sankhuwasabha	45,826	19,240	26,586
Bhojpur	60,854	22,340	38,514
Dhankuta	50,988	28,660	22,382
Total	157,668	70,240	87,428

Source:
(1) LRMP: - Land Resources Mapping Project, Nepal-Canada 1986
(2) DFAMS: - H.M.G. of Nepal, Department of Food and Agricultural Marketing Services, Agri. Statistics Division, 1986

The Arun Basin lying within Nepal has been divided into 21 subcatchments, and four land-use categories, calculated for each of the sub-catchments (Table 7). The total area amounts to 5,028.34 km^2, where agricultural land covers 25.31 per cent and forestland (inclusive of shrubland) covers just over twice as much, i.e., 50.48 per cent of the entire area. Dunsmore (1987) on the basis of Stewart (1987) has tabulated the arable cultivated area as 41.08 per cent and the forest area (woody vegetation and forest vegetation) as 43.23 per cent of the mapped area of 4171.40 km^2 in the Kosi hills. Approximately 31 per cent of the Sankhuwasabha district was not covered in the map. Sub-catchment numbers from 1 to 10 fall in this area where forestland coverage ranges from 22.35 to 70.75 per cent. (Table 7).

FIG.9B Crop Calendar in Arun Basin





Land utilization in the Arun Watershed showing various sub-catchments (Courtesy P.B. Shah)

Table 7 : LAND USE IN VARIOUS SUB-CATCHMENTS

No.	Sub-catchment Area Ha.	Forestland (incl. shrubland) Ha	%	Agri. land Ha	%	Grassland Ha	%	Others Ha	%
1.	49246.1	11484.2	23.31	322.5	0.65	8456.7	17.17	28982.7	58.85
2.	14663.2	7994.7	54.51	260.0	1.77	6368.5	43.42	40.0	0.27
3.	10954.4	2449.8	22.35	-	-	4889.6	44.63	3615.0	33.0
4.	28539.1	8444.2	29.58	167.5	0.58	5490.6	19.23	14436.8	50.58
5.	19045.9	8790.3	46.15	546.3	2.87	1307.5	6.86	8401.8	44.11
6.	16100.3	12385.2	76.92	2042.5	12.68	1127.6	7.0	545.0	3.38
7.	8641.8	4600.4	53.22	825.0	9.54	2457.5	28.43	759.3	8.78
8.	17548.1	9447.4	53.83	721.3	4.11	3582.3	20.41	3797.1	21.63
9.	19222.5	13416.6	69.79	207.5	1.07	2230.0	11.60	3367.9	17.51
10.	24548.3	17368.4	70.75	5207.8	21.21	1322.0	5.38	650.1	2.64
11.	37401.1	26051.0	69.65	4832.4	12.92	2188.1	5.85	4329.6	11.57
12.	53317.6	32836.3	61.58	18014.9	33.78	155.14	2.9	915.0	1.71
13.	31012.3	19269.3	62.13	10285.5	33.16	1269.4	4.09	188.1	0.60
14.	18590.4	7640.6	41.09	10689.8	57.49	37.5	0.19	222.5	1.19
15.	32951.2	16214.3	49.20	14694.2	44.59	1582.7	4.80	460.0	1.39
16.	57380.3	28467.1	49.61	25520.0	44.47	3393.2	5.91	-	-
17.	17559.8	8749.8	49.82	8172.5	46.54	392.5	2.23	245.0	1.39
18.	14422.6	6093.1	42.24	7359.5	51.02	914.7	6.35	55.3	0.38
19.	12140.7	4550.5	37.48	6712.6	55.28	660.0	5.43	217.6	1.78
20.	13304.9	5045.3	37.92	7543.3	56.69	366.3	2.75	350.0	2.63
21.	6243.8	2565.0	41.05	3123.8	50.02	472.5	7.56	82.5	1.31
	502834.3	253863.5	50.48	127248.9	25.31	50060.6	9.95	71661.3	14.25

Sub-catchments, as identified by serial numbers in col-1, are:

1. Barun
2. Sursing etc.
3. Bakang
4. Madokchheje
5. Irkhuwa
6. Kasuwa
7. Leksuwa
8. Apsuwa & Waling
9. Ikhna
10. Indua etc.
11. Sankhuwa
12. Sabahaya
13. Chirkhuwa etc.
14. Yangua etc.
15. Piluwa
16. Pikhuwa
17. Hanraya etc.
18. Leguwa etc.
19. Mahamaya etc.
20. Munga etc .
21. Kalapani

In the Arun Basin, Nelson (1980) rated the watershed condition to be 67 per cent excellent and 30 per cent good for the northern region, 53 per cent excellent and 47 per cent good for the midland region, and 4 per cent excellent, 76 per cent

good, and 20 per cent fair for the southern region. Analysis of land-use types on the basis of sub-catchments broadly supports Nelson's evaluation.

The ratio between agricultural land and forested land has often been regarded as a useful criterion to evaluate the general condition of a hilly region. To support one hectare of cultivated land, it requires 2.8 ha of forestland according to Wyatt-Smith (1982), 3 ha according to Shepherd (1985), and 6 ha according to Applegate and Gilmour (1985).

Cropping Patterns

Farming conditions differ greatly within a short distance. In the tropical zone, irrigated fields lying below 1,000 m yield two crops of paddy and one crop of wheat per year. On slope terraces two crops of maize may be harvested. Potatoes are grown as winter crop. Besides millet, sugarcane, groundnut and some oilseeds (*Guizotia abyssinica*, sesame, and mustard) are also grown in small quantities. Some vegetables and fruits, especially bananas are grown in kitchen gardens. The bananas, of the Arun valley are perhaps the largest and most delicious of their kind in Nepal.

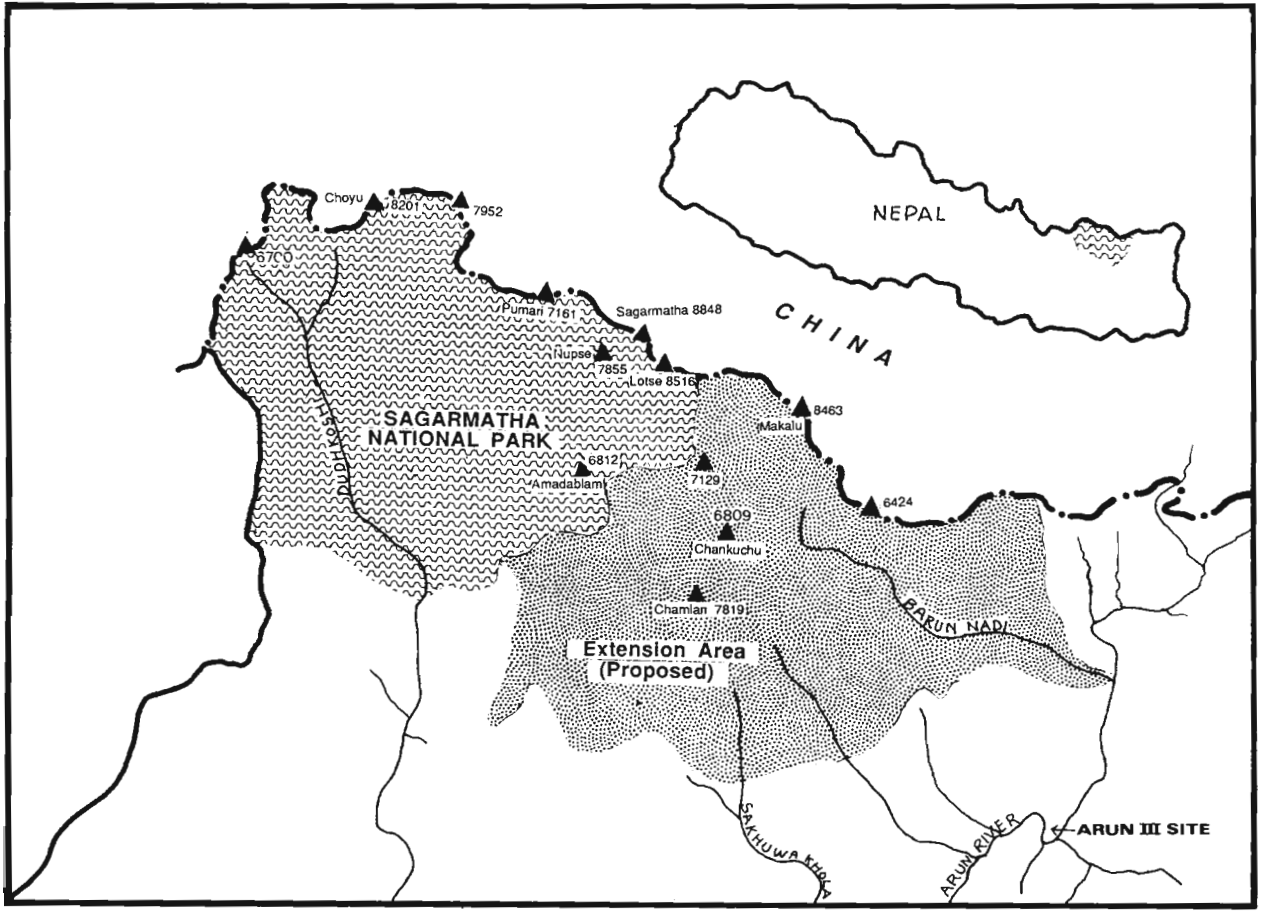
The sub-tropical zone is essentially a zone of maize and millet. Over 33 per cent of the land lies in this zone. Fields with adequate irrigation facilities grow paddy in summer and potatoes in winter. Otherwise over 37 per cent of crop-land is used for maize cultivation, and 26 per cent for millet. The spring rain plays a crucial role for both crops. Frequently, maize and millet are grown as relay crops.

The temperate zone does not grow paddy. Maize and millet remain the principal crops, the growing period for which is longer due to colder climatic conditions. Potatoes are grown in winter.

The sub-alpine zone in the Arun Basin is poorly cropped. For most of the months, this zone is covered with cloud and mist during spring and summer. Snowfall is heavy during winter, and snow stays too late to allow any crop in the winter.

The alpine zone receives some sun during the spring and summer. Naked barley and potatoes are grown from March to September. However, land suitable for cultivation is extremely limited in this zone.

FIG. 9A PROPOSED EXTENSION AREA OF THE SAGARMATHA NATIONAL PARK



The crop calendar (Fig. 9 b), developed on the basis of local information at various places en route to the Makalu Base camp, suggests that March-April are the busy months for all climatic zones. Off-farm labour is available during the middle of monsoon after the transplantation of paddy, and in winter after planting potatoes and wheat.

Figures published by the Department of Food and Agricultural Marketing Services of HMG suggest that agricultural areas have expanded considerably, while the yield has decreased quite significantly (Table 8). Both the indices indicate a process of environmental degradation.

Table 8 : AREA AND YIELD OF IMPORTANT FOOD CROPS IN 1970/71 AND 1985/86

Crops	Years	Area ha	Average Yield kg/ha
Paddy	1970/71	10,610	2400
	1985/86	126,500	1800
Maize	1970/71	24,050	2000
	1985/86	41,910	1600
Millet	1970/71	6,650	1200
	1985/86	12,600	900

Source : DFAMS 1986

The comparison of areas is rather tentative, since district boundaries have changed considerably within the last 15 years. The figures of DFAMS are based primarily on estimations of agricultural officials stationed in the districts. Actual physical measures, through aerial photography or cadastral surveys, would produce more realistic data.

Cash Crops

Three items of cash crops have caught the attention of local farmers in the Arun Basin. Citrus fruits, specially tangerines and sweet oranges, have a long history of production. For this reason the National Citrus Development Programme is lo-

cated in Dhankuta. Fruit processing units at Biratnagar and Itahari have created increasing demand for fruits and the road link to Dhankuta and further north to Basantapur has facilitated the transport of fruits. Prospects for horticulture in Southern Arun are great.

Big cardamom (*Ammomum subulatum*) has become one of the most promising cash crops in terms of both economy and ecology of the area. Export figures of cardamom show a very encouraging situation. A news item in the Gorkhapatra daily (Nov. 30, 1986) indicated that cardamom worth of N. Rs. 100 million (approx. US $ 5 million) was being exported from a border town (Chandaragadi) in eastern Nepal. Trade statistics from 1971/72 to 1981/82 show that the quantity of exports doubled from 338 tonnes (1972/73) to 685 tonnes (1975/76) in three years time. Exports reached lowest levels, i.e., 305 tonnes in 1981/82 when prices also dropped considerably. Home consumption of all surplus production is not possible, and the alternative use by processing its oil (Cineol) becomes uneconomical due to the fact that this oil is available from cheaper material, i.e., eucalyptus leaves. However, the flavour of cardamom is unique, and its export potentialities remain high. An institutional framework in keeping with the international marketing system has to be developed to safeguard cardamom production in eastern Nepal.

Cardamom is generally grown in wet ravines colonized by the alder trees (*Alnus nepalensis*), which provide shade and fix nitrogen. Alder leaves provide excellent manure and its fast- growing wood provides fuel for drying. Besides, the agroclimatic range of cardamom and alder is sympatric. Thus alder is regarded as an indicator tree for the cultivation of cardamom. At higher elevations above 1,800 m, cardamom is grown in association with the Raktachandan tree (*Daphnephyllum himalaica*). Till now, it is an experimental venture of local farmers.

Cardamom is an established crop in the Tamur Basin, and its introduction to the Arun Basin does not have a long history. However, farmers are attracted towards it and a single panchayat (Madi Mulkharka) is said to have 200 families engaged in its cultivation. The panchayat earned Rs. 1.2 million from the sale of cardamom in 1986. Cardamom is not affected by occasional hailstorms that destroy a number of other crops like maize, mustard, and potato.

Potato is an important crop for the mountainous region of Nepal. Its range of altitude covers all agro-climatic regions from tropical to sub-alpine. At lower elevations it is grown as a winter crop, while at higher elevations above 2 ,000 m it is a summer crop. The average yield of potato in Nepal is rather low, 6 tonnes/ha. Genetic improvements for higher yield and for disease resistance should quickly elevate its productivity. Some tubers, processed through tissue culture techniques developed in the Royal Botanical Gardens, Nepal, have indicated that they can produce over 16 tonnes/ha under normal farming conditions, as experimented in the Pakhribas Agricultural Centre. The cultivars, MS. 91 and Sangema, were found to be least effected by diseases and the yield is considerably higher (Table 9).

Table 9 : TRIALS OF TISSUE CULTURE POTATO IN THE PAKHRIBAS AGRICULTURAL CENTRE, DHANKUTA

Potato Cultivar	Disease per cent	No. of tubers per plant	Yield t/ha
M.S. 42	80	9	10
BR 63.65	80	5	7.92
M.S 82	40	4	9.71
M.S.35	45	6	9.27
L.853	40	5	9.26
M.S. 91	1	6	16.13
Sengema	1	4	13.90

Courtesy : Dr. S.B. Rajbhandari, Dept. of Medicinal Plants, HMG

Tissue culture as a modern technique can produce any amount of disease-free seed tubers for high-yielding cultivars. This technique is also used as a tool to clean potato seeds from their inherent virus diseases. One can easily overcome the problem of genetic erosion in potatoes.

Land Tenure System

The land tenure system in the districts of the Arun Basin is based on a traditional communal tenure system called the 'Kipat' system. Historically, the 'Kipat' authority of the community over-rides any claim the state might extend on grounds

of internal sovereignty or state landlordism (Regmi 1978). Kipat rights have been recognized not only on cultivated lands but also on wastelands, pastures, and forestlands. The main characteristic of the system is the non-alienability of land to members outside the Kirat community. Individuals belonging to the community have unchallenged rights to use their land. Thus the practice of shifting cultivation, locally termed as 'khorea' got deeply rooted in the agricultural system. Recent land reform legislation (1964 Land Acts) seeks outright abolition of kipat rights. The cadastral survey of the northern Arun Basin is still going on, and land reform legislation has yet to be implemented in most parts of Sankhuwasabha district. The land revenue raised from this district, which is much lower than that of the other districts of the basin (Table 10), suggests that land administration on scientific grounds is still far on its way in this district.

Table 10 : LAND REVENUE (in N. Rs X 1000)

District	Year	1984/85	1985/86	1986/87
Dhankuta	P	200	200	175
	A	374	383	335
Bhojpur	P	95	80	225
	A	409	396	427
Sankhuwasabha	P	20	20	15.5
	A	9.5	7.9	11

Source : Dept. of Land Revenue, HMG.
P = Projected, A = Actual revenue collected.

Traditionally kipat owners used to clear the forests and prepare cultivable land. Such lands gradually went into the hands of money lenders (non-Kirati) and the feudal lordship of Talukdars (kipat authority for land tax collection and administration). As early as 1834, the government recognized the plight of the kirati debtors and took some relief measures (Regmi 1978). However, the process of pushing poorer families farther and farther into the forestlands for shifting cultivation is still prevalent in the upper Arun. Thus a situation has emerged where shifting cultivation has to be stopped immediately, in order to protect remaining forests, and the indigenous population facing poverty, hunger, and disease require assistance by ex-

Rhododendron trees burned by a forest fire are seen on the foreground while chestnut forests are in the background. In between, a slope abandoned after slash-and-burn cultivation is under natural regeneration with *Eupatorium* as a pioneer plant

tending development activities in their area. The integrated rural development programme of KHARDEP does not cover most of those northern areas in the Sankhuwasabha district. Special programmes would be necessary to integrate people's participation in the mainstream of national development.

Slash-and-Burn Agriculture

Slash-and-burn, which is also known as shifting cultivation, has many local names in the Himalayas. In eastern Nepal, it is called Khorea, while in north-eastern India it is known as Jhum. The Rais and the Limbus of eastern Nepal, who enjoyed a special tenure right under the Kipat system, have the tradition of Khorea cultivation, as a supplementary source of crop production to meet the growing demand of the increasing population. Khorea, like the Jhum, is a highly labour-intensive and land-extensive form of cultivation. It is most detrimental to forest ecology and contributes to total extinction of a large number of biological species. The rate and extent of forest destruction through slash-and-burn has not yet been assessed for eastern Nepal. Similarly the ecological as well as economical impact of the slash-and-burn has yet to be studied systematically. However, inferences through general observation would be sufficient to conclude that this practice should be stopped immediately, without any delay, and the local people should get attractive alternatives to use their hard labour for making a living. In N.E. India, the level of income from Jhuming appears to be very low, as compared to prevailing wage rates (Saha 1976). In Nepal also, input of labour is great and production is meagre.

Khorea is mainly concentrated on hill slopes at altitudes between 1,500 m and 2,300 m. Most affected forests are (i) *Schima - Castanopsis,* (ii) *Castanopsis tribuloides,* (iii) *Rhododendron - Oaks and* (iv) *Oak - laurels.*

Forest on a selected site is cut in late winter (February) and left to dry until April. The dried debris is burnt down to ashes. Spring rain settles the ashes, and the field becomes ready for sowing maize/millet. The field is neither ploughed nor irrigated. Cultivators come back as soon as maize cobs are ready by late June or early July. They guard the field day and night to keep bears and porcupines away. Direct encounters with bears are not infrequent. On steep slopes, maize is sown by mouth-spitting in a hole dug by a small stick. The cultivator has to move up and down the hill by means of a rope tied round his waist. The Khorea cycle varies from 4-10

years. However, the tendency to go for a climax forest, rather than returning to previous clearances, is still quite high. In N.E. India, a terrace system cannot be sustained without heavy input of fertilizers and a Jhum cycle under five years is not economically viable and causes serious environmental problems (Mishra and Rama Krishnan 1983). Thus the cultivators must be pushed back to fertile farmlands and be motivated for intensive agriculture.

The deterioration of micro-climatic conditions, surface runoff, ground water runoff and loss of soil fertility are some of the obvious consequences of slash-and-burn cultivation (Lu and Zeng 1986). The loss of forest cover from hill slopes and the direct beating of monsoon rains cause great losses of the top-soil, and it triggers landslides on steep slopes. The water regime of the catchment is severely affected. Soil and nutrient losses by rainfall erosion in Nepal are estimated to be five times greater on lands under shifting cultivation (slash-and-burn) than on sloping terraces (Carson 1985). Although the estimation does not seem to have any experimental basis, it certainly provokes a concern over the practice of shifting cultivation in Nepal.

Based on enquiries with local people, it has been recognized that the land has become too poor to allow any cultivation after two to three years. Khorea lands, when left fallow, are rapidly colonized by *Eupatorium adenophorum* and then natural succession takes place. There is evidence of regeneration of original forest in *Schima-Castanopsis* zone, while most of the southern slopes give rise to *Rhododendron arboreum* forests. The return of original oak forests does not seem to have occurred in the Arun Basin.

Some authors, like Bhowmick (1976), adhere to the opinion that shifting cultivation is a response of the tribal people of the hill areas to the problem of erosion of fertile top soil from steep slopes. This technique is perhaps more scientific than actual ploughing and tilling on steep slopes, where any mechanical disturbances will result in washing away of the fertile top soil. Besides, it has also been experienced by downhill farmers that the slash-and-burn practice on mountain tops enriches their fields.

In a society endowed with primitive technology and absolute poverty, where human labour is the only available resource and "free land" the only option, shifting

cultivation remains the most viable method for subsistence. However, the Arun Basin is nearing a point of saturation and shifting cultivation (slash-and-burn) should be stopped immediately. Management strategies should, however, address the socioeconomic problem of the affected mountain population, who are pushed farther and farther due to economic pressures.

Livestock, Pasture, and Fodder situation

Livestock plays a pivotal role in the farming system of mountainous regions. The interdependence of crop-production, livestock, forest management, and the overall ecological condition is well recognized in the Arun Basin. Below 2,000 m altitude, cattle are more vital for ploughing terraces than for their milk. Cow dung is much valued as manure and is not used as a fuel substitute. Over 90 per cent of cow dung is directly used in manure. Milk is produced for home consumption only. Goats, chicken, and pigs are the main source of meat and protein. Thus each household has an average of three to five animals, as was observed on our route between Hile and Tasigaon. A market study in Dhankuta district, however, concluded that 27 per cent of the value of all products sold in the weekly market was of animal origin (Dunsmore 1987). A fortnightly Hat (traditional market at regular intervals) in Seduwa and in Num (Sankhuwasabha district), on the other hand, did not have

Table 11 : LIVESTOCK AT VARIOUS ALTITUDES

Altitude	Animal	Feed dependency	Purpose of livestock
3000-4000 m	Yak Sheep/Goats	Total grazing on pasturelands	Commercial Milk/Ghee, Wool, Hide, Meat, Wool Transport
2000-3000 m	Bull		Semi-Commercial Draught power
	Cows	Pasturelands and	Milk/Ghee, Manure, Hide
	Buffaloes	Fodder trees	Milk/Ghee, Manure, Hide, Meat
Below 2000m	Bulls		Domestic Draught power
	Cows	Wastelands	Milk, Manure, Hide
	Buffaloes	Crop residue and	Milk, Manure, Meat Hide
	Goats/Pigs	fodder trees	Meat

more than 10 chicken and two goats among some 1,000 people in the Hat. In Khandbari, the district headquarters, meat supply for the Dasain festival was being met by mountain goats and sheep from Chepuwa and Hatia regions in northern Sankhuwasabha. Thus the purpose of keeping animals differs in different ecological regions, which may be summarized as shown in Table 11.

Data on livestock numbers largely remain tentative. However, it has been generally recognized that the livestock population exceeds the human population and the shortage of fodder and feeding materials has been contributing not only to the depletion of natural vegetal cover but also to the retardation of natural regeneration of forests. The data published for the KHARDEP region, when examined against national figures, quickly leads one to think of fodder problems. The livestock population (735,000) has already exceeded the human population (545,000), as per the 1981 Census in the KHARDEP region (Dunsmore 1987).

Table 12 : LIVESTOCK POPULATION IN KHARDEP AS COMPARED TO NEPAL (figures in thousands)

Animal	Nepal*	KHARDEP	Percentage
Cattle	5,986	300	5
Buffalo	2,705	85	3.26
Goats	3,654	250	6.95
Sheep	561	40	7.27
Pigs	358	60	6.66
Yak	?	?	
Total	13,264	753	5.54

* Source : Nepal Agriculture Sector Strategy 1982

Table 12 also suggests that the Arun Basin has a higher percentage of pigs than elsewhere in Nepal. It has to do with the tradition and culture of the Kiranti people (Rais and Limbus). Curiously enough, even the Sherpa community in upper Arun rears pigs. This is rather unusual in Nepal. A random survey of the livestock population in the Upper Arun valley along the caravan route shows that each household had livestock numbers equalling human numbers. However, at high altitudes, such as in Tashigaon, livestock numbers far exceed the human population.

This is to be attributed to the availability of more grazing areas at high altitudes and to the agricultural system based heavily on livestock (Table 13).

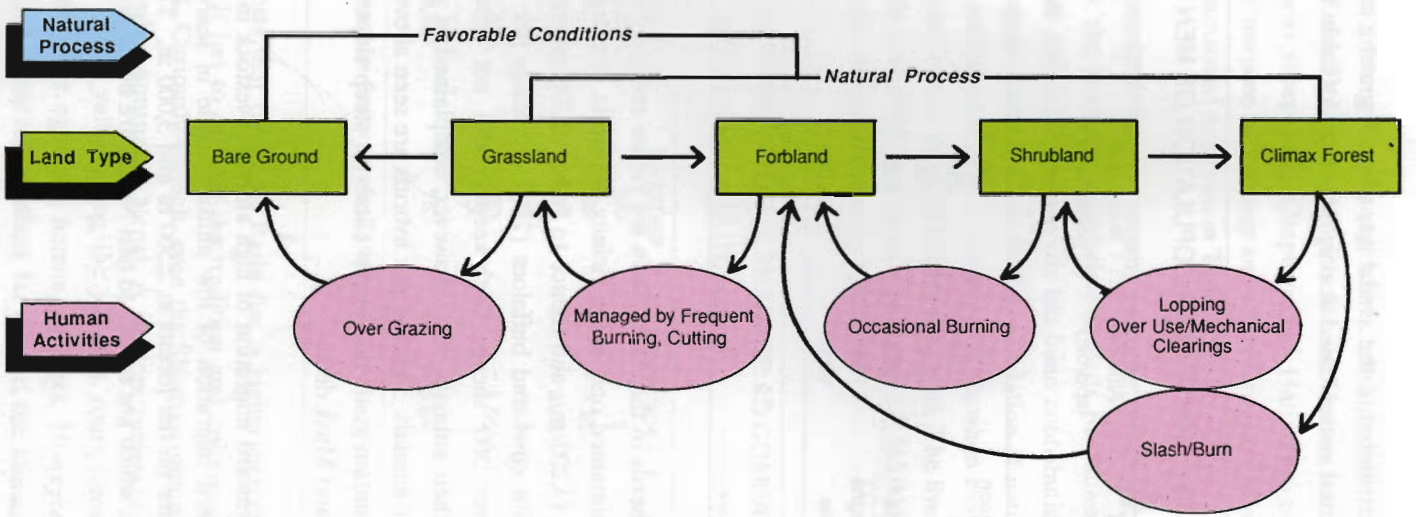
Table 13 : HOUSEHOLD POPULATION OF MEN AND MAMMALS

Village	Altitude (approx.) m.	Number of households (approx.)	Population per household	
			Human	Mammals
Tashigaon	2100	35	8	15
Sedua	1500	250	8	10
Num	1500	700	6	6
Chichila	1800	600	10	10
Hedangna	1200	600	5.8	9.4
Syaksila	1500	84	9.5	9.5

Animal herds in the Arun Basin are rather remotely placed from main villages. Herds are maintained only in the vicinity of forests. Our trek from Dobate (3,660 m) to Gaikharka (3,200 m), and thence to Bakle (2,500 m), took us through more than 25 "Goths" with cows and buffaloes (25 to 27 heads per "Goth") and five "Goths" each with over 300 sheep. Goth-keepers did not complain of fodder/pasture shortage for their animals. They, however, complained of wolves and wild dogs that often kill their animals. Yak and yak hybrids are seen above 4,000 m in the main valley, while mountain goats and sheep climb on steep slopes, competing with wildlife such as Thar and Musk deer.

The downward migration of high altitude livestock in search of a warmer area and the upward migration of low altitude cattle in search of more fodder exert double pressure on the forests at 2,500 m and 3,000 m. Thus the temperate broad-leaved forests, which are unique to east Nepal, are being depleted by livestock.

FIG. 10 **General Pattern of Grassland Succession**



Grasslands

The ecology of east Nepal grasslands was studied by Tsuchida (1983). Studies of the Arun Basin show that most of the grasslands are occupied by short-grass types (less than 2-3 cm high) and overgrazing has led to the transformation of good grasslands into unpalatable bushlands. Grassland maintenance through burning and re-fertilizing, and also through rotational grazing, is seldom carried out. More studies are recommended for finding concrete methods for grassland management and conservation. The general pattern of succession on grasslands may be predicted as shown in Fig. 10.

There is no evidence of grass cultivation in the whole of the Arun Basin. All accessible grasslands are in a semi-natural condition, with varying degrees of succession, both retrogressive as well as progressive. Cultivation of tall grasses is to be encouraged on slopes lying above 2,000 m, which is generally the limit for cereal cultivation. Burning of forests near Goths for increasing grazing area should be stopped as soon as possible. Studies on the succession of plants in the process of forest regeneration should be initiated so as to identify the right time for intervention in order to promote the growth of desired plant communities.

Zonation of Grasslands

The Arun Basin is more humid than most of the other regions in Nepal. Under such an environment, four zones of grassland vegetation have been identified on the basis of altitudinal variation (Table 14).

A-Zone

Grasslands below 1,100 m altitude are characterized by the dominance of annual plants, which are normally propagated by seeds. Prominent species are *Cynodon dactylon, Chrysopogon aciculatus,* and *Desmodium trifolium.*

Overgrazing of this zone results in a dry type of vegetation, with clumps of *Eupatorium adenophorum, Anaphalis contortus,* and *Artemesia* spp. This zone can well be managed by burning down forb plants and encouraging long grasses. Overgrazing soon leads to bare grounds. On the other hand, if the area is left abandoned,

Table 14 : ALTITUDINAL ZONES OF GRASSLANDS AND THEIR SUCCESSIONAL TYPES AFTER TSUCHIDA 1983

Altitude m.	Zone	Grassland Type	Forbland Type	Shrubland Type	Climax Forest
		Calamogrostis sp.	Alpine herbs	Rhododendrons	Rhododendrons
		Festuca sp.		Junipers	Junipers
		Carex sp.			
	D	Agrostis sp.			
3800					
		Carex sps.	Senecio sps.	Rhododendrons,	Rhododendrons,
		Poa annua	Circium sps.	Rubus sps.	Accer sps.
	C	Plantago minor	Anaphalis sps.	Sorbus sps.	
		Rumex sps.	Tsuga sps.		
			Abies sps.	Betula sps.	
2600					
		Paspalum	Eupatorium sp.	Eurya sp.	Schima-
		Scrobiculatum	Thelyptris sp.	Maesa sp.	Castanopsis
		Setaria	Pteridium sp.	Osbeckia sp.	
		pallicifusca		Arundinaria sp.	Quercus sp.
	B	Arthraxon sp.	Artemesia sp.	Viburnum sp.	Lithocarpus sp.
		Cynodon dactylon	Ageratum sp.		
		Pycreus sp.			
1100					
		Cynadon sp.	Saccharum sp.	Maesa sp.	Shorea sp.
		Chrysopogon	Eupatorium sp.	Callicarpa sp.	Terminalia sp.
	A	aciculatum	Cassia sp.	Lantana sp.	
		Cyperus sp.	Ficus sp.		

the grassland changes over to shrubland with unpalatable plants. The shrubland leads to form climax forests of *Shorea robusta, Terminalia tomentosa, Engelhardtia spicata,* etc. The climax forest formation is rather unlikely in the face of present pressure on land from men and livestock.

B-Zone

The middle zone, lying between 1,100 m and 2,600 m, is heavily degraded. On well managed grasslands, grazing grasses such as *Paspalum scrobiculatum, Pycreus*

sanguinolentus, Cynodon dactylon, and *Setaria pallidifusca* are found. Evidence of overgrazing and degradation is obvious due to the abundance of *Eupatorium, Artemesia, Anaphalis,* ferns, etc. In course of time (about 10 years), the forbland changes into shrubland with thorny and unpalatable species of plants. If undisturbed for about 20-30 years, climax forests take the ground.

C-Zone

This zone lies between 2,600 m to 3,800 m, in the temperate region. It is characterized by the dominance of *Carex* spp. and a number of flowering herbs. This zone progresses into a forbland of compositae plants (sunflower family), such as *Circium* sp., *Senecio* sp., and *Anaphalis* sp. Given a long undisturbed period this zone develops into mixed deciduous forests of *Acer* spp., *Tsuga dumosa,* Rhododendrons, and Magnolias.

D-Zone

The area lying above 3,800 m, i.e., between the natural tree-line and the snow line, consists of vast stretches of alpine grassland, with the dominance of *Calamogrostis* spp., *Carex* spp., and *Festuca* spp. This zone is very rich in colourful flowering

Sheep herding on the Milke-danda at 3,500m in July and August

Goats are fed with tree fodder near Tumlingtar

Ficus auriculata is an important fodder tree which grows to 30 m in its natural habitat

plants like *Primula* spp., *Gentiana* spp., *Potentilla* spp., and *Geum* spp. Grazing by animals promotes the occurrence of those unpalatable but colourful plants. Vast stretches of ubiquitous cover of *Primula* spp. in east Nepal are the results of overgrazing by sheep and yak.

Fodder Trees

The tradition of using tree leaves as fodder has led to the identification and exploitation of a large number of indigenous tree species in the midlands of Nepal. Panday (1982) has listed 134 species of trees and shrubs used as fodder in Nepal. In the Arun Basin itself, over 75 species of native trees and shrubs serve as a source of fodder (Appendix III). They are distributed from below 1,000 m altitude to 4,000 m altitude. By and large, most of the fodder is collected from public forests in the vicinity of villages or around herding areas, called "Goths". Villages at lower elevations, with limited access to forests, have practiced planting fodder trees. Among the most popular species for village plantation, mention may be made of *Saurauja napaulensis* (Gogane), *Ficus roxburghii* (Neware), *Ficus benghalensis* (Bar), and *Toona ciliata* (Tooni). Twenty-five species (Asterisk marked in the Appendix) of the fodder trees of Arun Basin may be categorized as first-grade species, which have more than 30 % dry matter and less than 10% ash content in their leaves (Bajracharya et al. 1985). A large number of other species still await chemical analysis. The accompanying graph on the distribution of fodder trees shows that the minimum number (less than 10 species) falls in the sub-alpine region, while the largest number of species (40 to 50 spp.) occur at lower elevations (700 m to 1,600 m). Thus it is fortunate that there is a rich resource of genetic material for tree planting in the critical hilly areas of heavy human occupation.

Tree lopping from the public forest generally results in a very degraded forest, with 'mast-like' trees devoid of lateral branches and leaves. The thinning of leaves quickly induces a heavy growth of forest weeds, particularly Banmara (*Eupatorium adenophorum*), which inhibit regeneration of seedlings. It also exhausts nutrients for a healthy growth of trees, which degenerate and die in the course of time. Thus the demand for fodder for the ruminant population in the Arun Basin should be met by afforestation of fodder species and by ensuring wise management practices. Bad management practices result in various hazardous effects. One such effect is observed on a slope near Ahale village at 2,400 m altitude, where a patch of forest con-

sists of nothing but *Lyonia ovalifolia* trees, which produce poisonous leaves for cattle. In the same way, the Gogane village at an altitude of 1,900 m does not have any Gogane tree (*Saurauja napaulensis*) but dry ferns and weeds of no fodder value. In the whole of the Arun Basin, there hardly exists any sizable forest of Gogane except in an small area in the lower Barun valley. Thus there is a clear indication that unless those indigenous fodder trees are brought into cultivation, fodder problems will soon become acute, especially in the midland regions.

A number of fodder trees, with a wide range of altitudinal distribution, are available for planning plantations. The following trees may be considered useful as afforestation species for most parts of the Arun Basin (Table 15). Propagation methods are followed, as per FAO (1959), Campbell (1981), and Kk. Panday (1982).

Table 15 : RECOMMENDED FODDER TREES FOR PLANTATION IN ARUN BASIN

Species	Altitudinal range (m)	Fodder collecting season	Propagation means	Remarks
Quercus glauca	400-3000	Spring	seeds	on northern slopes
Q. lamellosa	1400-2600	Autumn/ Winter	seeds	on southern slopes
Alnus nepalensis	500-2600	"	seeds	in ravines
Ficus auriculata = roxburghii	250-1800	Winter/ Summer	seed/cutting	farmland
Saurauja napaulensis	700-2100	Winter	"	farmland
Bauhinia purpurea	200-1000	"	"	"
		"	"	"
B. variegata	150-2200	"	"	"
B. malabaricum	200-1000	"	"	"
Quercus semecarpifolia	1700-3800	Winter/Spring	seeds	Dry rocky slope
Acer campbellii	2100-3600	Summer	seeds	Deciduous, plant on northern slopes

Grasslands that are used for community grazing should be managed through burning down or weeding out unpalatable plants. Similarly, existing forests should be lopped for fodder to an extent as to prevent excessive sunlight falling on the forest floor. Local panchayats should take an active part in ensuring protection of grasslands from overgrazing and of forests from overlopping.

Pasture development activities in the sub-alpine zones should not be directed towards introducing exotic grasses. New areas of pasture lands may be opened up by making mountain trails, and overgrazing should be avoided by rotational grazing.

The demand for meat, milk, ghee, and eggs is ever increasing due to large mountaineering parties and development of market centres along roads and in the headquarters. The realization of the Arun III project will create an unprecedented demand for animal products. Livestock, fodder, and pasture development, therefore, warrants immediate attention from the public and the private sectors.