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FARMING-FORESTRY-LIVESTOCK LINKAGES IN MOUNTAIN REGIONS

Yamun Yadav

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International Centre for Integrated Mountain Development

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PREFACE

ICIMOD's approach to problem oriented research involves both knowledge reviews and field studies. The focused reviews and field studies conducted by the Mountain Farming Systems Division cover various aspects of agricultural development. Since early 1988, a series of 'state of the art' reviews of agricultural policies and programmes were sponsored by ICIMOD in different countries of the HKH Region. The purpose of these studies and the subsequent National Workshops in different countries was to understand some of the constraints and prospects of mountain area development. These exercises were also aimed at acquiring comparative perspectives of development approaches and strategies in different countries.

This paper was a part of this series of studies commissioned by ICIMOD. The paper discusses linkages among various components of the mountain farming systems and puts forward some important policy implications based on the findings of the study.

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I. INTRODUCTION

The hills and mountains lying in the northern part of Nepal cover about 77 per cent of the total physical area and contain about 56 per cent of the total population. The limited transport and communication infrastructure, unavailability of reliable markets and production inputs, high variations in micro-climates, accompanied by large family size on small fragmented farms on hill terraces and steep slopes have led the farmers in the mountain regions to adopt the subsistence-oriented mixed farming system which is characterized by substantial diversity and also a high degree of self-reliance. The system comprises of a great variety of crops including perennial fruit and fodder trees and different species of livestock on the farm. The system produces food year-round, and provides continuous employment for unskilled labour to tend crops and livestock. The system is highly labour intensive and depends to a large extent on the available forests and rangelands. Forest is an integral part of the farming system, just as much as arable land and livestock. Forests supply fuelwood, fodder, compost, timber, poles, and food to the system. Thus, crop production, animal husbandry, and forestry constitute the three main closely and inseparably integrated components of the mountain farming system. Although the farmers in the region have always understood these linkages and closely integrated agricultural, animal husbandry, and forestry practices, the interrelationships have only recently begun to be understood and appreciated at the professional level (Mahat 1985). However, despite the recognition of this fact, there has hardly been any quantified evidence on it.

The objectives of this study are: i) to examine the importance of components such as crop, livestock, and forestry and identify their linkages with respect to mountain farming systems and ii) to quantify those linkages in terms of contribution of each component of the farming system to other(s) and vice-versa. The scope of the study is to quantify the contribution of: i) forests and pastures to livestock and crops in terms of fodder, bedding, and compost materials, and to farming households in terms of fuelwood, timber, and other forest products; ii) livestock to crops in terms of draught power and manure, to households in terms of food and cash income, and to forests and pastures in terms of manure; iii) crops and farm trees to livestock in terms of feed and bedding materials and to households in terms of food, fuelwood, other materials, and cash income; iv) farming households to crops, livestock, forests, and pastures in terms of labour and management; and v) market to all the above components and vice-versa.

In order to generate information required for the accomplishment of the study objectives, data were collected from both primary as well as secondary sources. After reviewing the available literature on mountain farming systems, a reconnaissance survey was carried out in different places in Dhadhing, Makwanpur, Kavrepalanchok, Sindhupalchok, and Dolakha districts in order to select study sites that represent hills and mountains in terms of accessibility, altitude, aspect, climate, and agricultural and socioeconomic characteristics. based on the findings of the reconnaissance survey, three sites namely, Naubise in Dhadhing District as a horticultural crop-dominated farming system; Dhuskun in Sindhupalchok District as a cereal crop-dominated farming system; and Yelung in Dolakha District as a livestock-dominated farming system were selected for conducting site specific case studies. Thirty households were randomly selected and interviewed from each site. In addition, a number of local leaders and other key informants were also interviewed from each site in order to generate community level information.

The data generated through primary as well as secondary sources have been analysed and interpreted to form the basis of this paper. The paper, in the following sections, provides a brief account of the physical, socioeconomic,and agricultural characteristics of the study sites; elaborates the linkages among the various components of mountain farming systems; and finally puts forward some important policy implications based on the findings of the study.

II. THE STUDY AREAS

General Features

The horticultural crop-dominated site (Naubise) is located in Ward No. 2 of Naubise *Panchayat* in Dhadhing District, Bagmati Zone. It is about 25 km south-west of Kathmandu and is connected by an all-weather highway which links Kathmandu with the *Terai* and a number of hill districts. The cereal crop-dominated site (Dhuskun) is located in Ward No. 2 and 8 of Dhuskun *Panchayat* in Sindhupalchok District, Bagmati Zone. It is about 6 km east of Barahbise which is connected to an all-weather road connecting Kathmandu with Kodari. The livestock-dominated site (Yelung) is located in Ward No. 5 and 6 of Shyama *Panchayat* in Dolakha District, Janakpur Zone. The site is about 5 km north of Jiri which is connected to Kathmandu by an all-weather road.

The elevation of the Naubise Site ranges from 970 m to 1,100 m with moderately sloping hill terraces. Since the site is located on a ridge, the aspect is variable. Soils of the area consist of loams and silty loams with good drainage. The altitude of Dhuskun Site ranges from 1,150 m to about 2,200 m. Lands are moderately to strongly sloping and soils are 50-100 cm deep and well drained. Loamy skeletal soils predominate in the area. The aspect of the site is mostly south-facing. The Yelung Site is located at an altitude ranging from 2,000-2,400 m with moderately to steeply sloping mountain terrains facing east and south-east. Well-drained loamy-textured soils are common in the area.

The climate of the Naubise Site is sub-tropical and sub-humid with an annual mean temperature of 21°C and a total annual rainfall of 1,585 mm. The Dhuskun Site is characterised by a warm temperate humid climate with an annual mean temperature of 19°C and a total annual rainfall of 2,230 mm. The Yelung Site has a cool temperate perhumid climate with an annual mean temperature of 14°C and an average annual rainfall of 2,139 mm. The distribution of rainfall is highly seasonal at all the sites. Of the total annual rainfall, about 87-90 per cent occurs during the five monsoon months (May-September). Hailstorms occur at all the sites, mostly during March-May and sometimes during October-November at an average interval of 3-4 years. There is generally no problem of frost and snowfall at Naubise and Dhuskun. However, both frost and snowfall are constraints for winter crops at Yelung. Frost occurs during December-Februrary and snowfall during January-February.

The agricultural support services at the Naubise Site are provided through the Agricultural Development Bank (ADB/N), the Commercial Bank, the Cooperative Society and its Depot, the Agricultural Sub-centre, the Livestock Sub-centre, and the Horticultural Farm all located in the same *Panchayat*. Khanikhola and Dharke are the nearest market centres and Kathmandu, which is about 25 km away, is the biggest market centre where most of the fruits and vegetables produced on the site are sold. The agricultural support institutions serving the Dhuskun Site include a Small Farmers' Development Programme run by ADB/N, a livestock sub-centre, and an agricultural sub-centre in the same *Panchayat*. Barhabise and Lamosangu are the nearest market centres. The Yelung Site is served by a livestock sub-centre and three seasonally-operated sub-branches of the Cherdum Cheese Factory all located in Shyama *Panchayat*. In addition, the Livestock Farm, Veterinary Dispensary, and sub-branch offices of the ADB/N and Nepal Bank Limited at Jiri also provide services to the farmers in the study area. Jiri is the nearest market centre. Among the three study sites, Naubise is the most privileged one in terms of accessibility and availability of inputs, services, and market facilities.

The Naubise Site consists of some newly established forests and very little grazing land. The site does not have any access to well-grown forests within the vicinity of 7-8 km. The Dhuskun Site consists of both newly established as well as well-grown forests. However, there is limited grazing land in the area. There are abundant forests and pastures at the Yelung Site. The actual area of forests and pastures at different sites could not be estimated due to paucity of reliable data.

Socioeconomic Characteristics

The information on socioeconomic characteristics of the sample households at the three study sites are shown in Table 1. The average family size ranges from 5.07 persons at Dhuskun to 5.5 persons at Yelung and 7.13 persons at Naubise. Females constitute about 51 per cent of the family members at Naubise and Dhuskun and about 45 per cent at Yelung. The average number of economically active members per household ranges from 3.13 at Dhuskun to 3.77 at Yelung and 4.77 at Naubise. The proportion of economically active household members with agriculture as their main occupation is the highest at Dhuskun (90%), followed by Yelung (75%), and Naubise (69%). The remainder are engaged in study, services, business, and other activities.

Table 1: Socioeconomic Characteristics of the Sample Households at Different Study Sites (Per Household Average Unless Indicated Otherwise)

Particulars	Naubise	Dhuskun	Yelung
Average Family Size (persons)	7.13	5.07	5.50
Male/Female Ratio	0.96	0.97	1.20
Literacy (%)	64.00	49.00	48.00
Economically Active Members per Household (No.)	4.77	3.13	3.77
Dependency Ratio (Dependents/Economically Active Members)	0.49	0.62	0.46
Occupations of Economically Active Members:			
Agriculture (%)	69.00	90.00	75.00
Study (%)	28.00	0.00	17.00
Services (%)	3.00	5.00	1.00
Others (%)	1.00	5.00	8.00
Average Size of Operated Land Holding (ha):	0.97	0.54	0.28
Lowland (ha)	0.39	0.17	0.28
Upland (ha)	0.58	0.37	0.00
Average No. of Parcels per Farm	4.64	4.06	11.90
Average Size of Parcels (ha)	0.21	0.13	0.02
Average Size of Livestock Holding (LSU)	3.68	2.45	6.95
Draught Animals per Household (No.)	0.53	0.57	1.07
Population Density per ha of Cultivated Land (Persons)	7.35	9.39	19.64
Livestock Density per ha of Cultivated Land (LSU)	3.79	4.54	24.82

The average sizes of operated land holdings at Naubise, Dhuskun, and Yelung are 0.97 ha, 0.54 ha, and 0.28 ha respectively. Rented-in lands constitute about 20, 13, and 11 per cent of the operated land at the three sites respectively. Share-cropping is the most common system of tenancy. While lowlands constitute about 40 and 31 per cent of the operated land at Naubise and the Dhuskun respectively, there is virtually no lowland at Yelung. At Naubise, all the lowlands are perennially irrigated and some parts of the uplands are seasonally irrigated, whereas only

lowlands are seasonally irrigated at Dhuskun. There exist no irrigation facilities at Yelung. The average number of fragments per farm is the highest at Yelung (11.9), followed by Naubise (4.60), and Dhuskun (4.06).

The average sizes of livestock holdings are 3.68 LSU (Livestock Unit) at Naubise, 2.45 LSU at Dhuskun, and 6.95 LSU at Naubise. Both human and livestock population densities per hectare of cultivated land are highest in Yelung followed by Dhuskun and Naubise.

Agricultural Characteristics

Crop Production

Crop production in the study area is highly diversified with dominance of cereals. In general, maize-based cropping patterns predominate on uplands and paddy-based on lowlands. The data on crop areas, cropping intensities, and the number of farm trees at different study sites are included in Table 2. Of the total cultivated land per household in Naubise, maize occupies about 62 per cent followed by paddy (43%), wheat (27%), vegetables (17%), and other crops (16%) with an average cropping intensity of 165 per cent. At the Dhuskun Site, maize occupies about 78 per cent of the operated land followed by millet (57%), paddy (32%), and other crops (5%) with an average cropping intensity of 172 per cent. However, at the Yelung Site, wheat is the most important crop occupying about 38 per cent of the cultivated land followed by maize (28%), potato (22%), millet (19%), and other crops (8%) with an average cropping intensity of 115 per cent. While paddy is not grown at Yelung due to lack of lowlands and prevalence of low temperature, vegetables are grown on a commercial scale at Naubise only, where perennial irrigation and reliable market facilities are available. Lower cropping intensity at Yelung may be attributed to longer growing period of crops due to prevalence of relatively lower temperatures and problems of frost and snowfall in winter.

Table 2: Information on Crops and Farm Trees at Different Study Sites (Per Household Averages Unless Indicated Otherwise)

Particulars	Naubise	Dhuskun	Yelung
Cultivated Land for Household (ha)	0.97	0.54	0.28
Crop Areas (% of cultivated land):			
Early Paddy	3.00	0.00	0.00
Normal Paddy	40.0	32.00	0.00
Wheat	27.00	3.00	38.00
Maize	62.00	78.00	28.00
Millet	4.00	57.00	19.00
Potato	3.00	0.00	22.00
Barley	0.00	0.00	4.00
Buckwheat	0.00	0.00	4.00
Sugarcane	4.00	0.00	0.00
Oilseeds	5.00	2.00	0.00
Vegetables	17.00	0.00	0.00
Cropping Intensity (%)	165.00	172.00	115.00
Total Trees per Farm (No.)	119.00	15.00	96.00
Fruit Trees (No.)	58.00	2.00	*
Fodder Trees (No.)	24.00	5.00	24.00
Other Trees (No.)	37.00	8.00	72.00

* Less than 0.5

The average number of trees per farm at Naubise is estimated to be 119 of which about 49 per cent are fruit trees, 20 per cent fodder trees, and the rest fuelwood/timber trees. The number of farm trees per household at Dhuskun averages only 15, of which about 13 per cent are fruit trees, 33 per cent fodder trees, and the rest fuelwood/timber trees. At the Yelung Site, each farm consists of 96 trees of which about 25 per cent are fodder trees and the rest are fuelwood/timber trees. Trees are more common on upland terraces and around homesteads at all the study sites.

Table 3: Crop Production: Per Hectare Input-use and Outputs at Different Study Sites

Crops	Seed (kg)	Manure (mt)	Fertilizer (N:P:K kg)	Pesticides (Rs)	Human labour (man-days)	Bullock Power (pair-days)	Yields (MT)	
							MP	BP
Naubise								
Early Paddy	61.8	2.29	63:18:00	130	223	38	2.97	3.24
Normal Paddy	62.5	1.49	64:29:00	101	194	41	2.70	3.21
Wheat	112.0	1.79	66:35:00	12	157	39	1.68	2.72
Maize	29.3	4.76	49:27:00	142	179	43	1.77	3.38
Millet	19.8	1.06	16:07:00	-	158	15	1.03	1.72
Potato	983.8	9.91	39:29:00	280	231	40	5.95	-
Sugarcane	4186.0	4.74	57:17:00	-	197	33	15.40	7.50
Mustard	14.9	0.36	38:38:00	-	112	39	0.66	0.82
Vegetables (Rs)	1125.0	11.42	71:44:23	1355	354	49	17.81	-
Dhuskun								
Normal Paddy	69.0	1.46	13:00:00	-	167	43	1.72	1.97
Wheat	88.0	2.16	22:10:00	-	143	37	1.23	2.27
Maize	33.0	5.07	17:08:00	-	172	46	1.49	2.55
Millet	16.2	0.61	1:00:00	-	164	-	0.95	1.71
Mustard	9.0	0.65	6:00:00	-	89	32	0.51	0.74
Yelung								
Wheat	97.3	2.61	-	-	148	41	1.15	2.10
Maize	24.5	6.10	-	-	167	44	1.53	2.83
Millet	17.8	1.66	-	-	149	-	0.88	1.69
Potato	1083.0	10.19	-	-	252	48	5.54	-
Barley	69.9	1.23	-	-	109	37	0.66	1.19
Buckwheat	62.2	2.60	-	-	107	36	0.90	1.39

Note: MP = Main Product
BP = By-Product

The average rates of input-use of different crops, and crop outputs per hectare are shown in Table 3. While the uses of organic manure, human labour, and bullock power are common at all the study sites, the use of chemical fertilizer is the highest at Naubise and nil at Yelung. Similarly, the coverage of improved seeds with different crops is the highest at Naubise followed by Dhuskun. At the Yelung Site, some areas under potatoes are using improved seeds, but only local seeds are used for all the other crops grown at the site. The use of pesticides for plant protection is practised at Naubise only. The average crop yields are observed to be higher at Naubise compared to those at the other two sites. This can be mainly attributed to better irrigation facilities and higher uses of modern inputs at Naubise.

Livestock Production

Livestock production is an integral part of the farming system in the study areas. Like crop production, livestock enterprise is also highly diversified with dominance of cattle at all the study sites. The information on livestock production at different study sites is included in Table 4. On an average, each farming household keeps 3.39 cattle, 1.67 buffaloes, 2.44 goats, and 1.77 poultry birds at Naubise; 2.20 cattle, 0.86 buffaloes, 2.73 goats, and 3.70 poultry birds at Dhuskun; and 6.47 cattle (including *Chauries*), 2.33 buffaloes, 2.96 goats, 0.07 sheep, and 2.20 poultry birds at Yelung. While all species of livestock produce manure, male cattle and buffaloes are primarily kept for draught power, female cattle and buffaloes for milk, goats and poultry for meat, and sheep are kept for both wool and meat. Discussions with the farmers revealed that the total number of livestock has declined over time at all the study sites, mainly due to increased scarcity of livestock feed that resulted from deterioration of the off-farm feed resources.

Table 4: Information on Livestock Production at Different Study Sites (Per Household Averages Unless Indicated Otherwise)

Particulars		Naubise	Dhuskun	Yelung
Size of Livestock Holding (LSU)		3.68	2.45	6.95
Herd Composition (No. of Animal Heads):				
Cattle:	Adult Male	0.53	0.57	1.07
	Adult Female	0.53	1.10	0.60
	Chauries	0.00	0.00	4.04
	Calves	1.20	0.53	0.76
Buffaloes:	Adult Male	0.00	0.07	0.03
	Adult Female	1.10	0.56	1.43
	Calves	0.57	0.23	0.87
Goats		2.44	2.73	2.96
Sheep		0.00	0.00	0.07
Poultry		1.77	3.70	2.20
Animal Feed Consumption:				
Stall-fed Green Roughages (TDN kg)		676.00	792.00	1405.00
Stall-fed Dry Roughages (TDN kg)		1379.00	913.00	253.00
Stall-fed Concentrates (TDN kg)		244.00	54.00	41.00
Grazing (hours)		298.00	686.00	2018.00
Bedding Materials (kg)		1182.00	757.00	797.00
Milk Yields per Lactation (litres):				
Cows		428.00	225.00	254.00
Chauries		-	-	307.00
Buffaloes		1065.00	524.00	595.00

Livestock in the study area are both grazed as well as stall-fed. In the existing practice, livestock feed mostly comprised of roughages derived from both farm and off-farm resources and partly of concentrates mostly produced on farms. The contribution of roughages to total feed (TDN) consumption, except those obtained from grazing, ranges from about 89 per cent at Naubise to 98 per cent at Yelung. Given the size of livestock holding, the feed (TDN) consumption through stall-feeding at Yelung works out to be quite low Since there are abundant pastures, and grazing is most widely practised at this site, it is expected that feed supply from grazing makes up for lower TDN supply through stall-feeding.

In general, livestock productivities are low in the study area. The average per lactation yields of cows and buffaloes, respectively, are reported to be 428 and 1,065 litres at Naubise, 225 and 524 litres at Dhuskun, and 254 and 595 litres at Yelung. The average milk production of *Chauries* is estimated at 307 litres per lactation.

III. LINKAGES AMONG THE COMPONENTS OF THE FARMING SYSTEM

Concepts and Assumptions

For the purpose of analysing the linkages, the components of the farming system have been identified as crops, livestock, forests and pastures, farming households, and the market. Any biomass of plant origin produced on the farmland is considered to be the contribution of crops. Thus, crop production encompasses the production of cereals, cash crops, vegetables, fruits, fodder, and fuelwood on the farm lands. The terms, forests and pastures, have been used to indicate public resources unless specified otherwise. Any output from the farm or the household that is sold or hired-out is assumed to go to the market. Similarly, any input into the farm or the household that is purchased or hired-in is assumed to come from the market.

All the estimations for quantifying the linkages are based on field data except the production of livestock manure which has been estimated at the rate of 4,000 kg fresh manure per LSU per annum (Dasgupta 1945). The ratio of livestock manure to grazing land has been estimated on the basis of time spent on grazing per annum. After deducting the quantity of manure for grazing land, handling and other losses have been considered at 15 per cent and the balance is assumed to go to crops. For converting feed materials into TDN, the TDN contents of various feed stuffs have been taken as follows: grass fodder - 13.56 per cent; tree fodder - 19.40 per cent; rice straw - 45.20 per cent; maize stover - 54.70 per cent; millet straw - 50.10 per cent; wheat, barley, and buckwheat straw - 44.10 per cent; maize grains - 84.90 per cent; wheat grains - 83.0 per cent; and barley grains - 77.7 per cent (Sen and Ray 1971). Similarly, for converting food commodities into calories, the calorie values per kg of food items in edible form have been taken as: rice - 3,600, wheat - 3,340, maize - 3,560, millet - 3,320, potato - 830, barley - 3,320, buckwheat - 3,320, oilseeds - 5,740, sugarcane - 600, fruits - 550, vegetables - 250, milk - 1,010, and meat - 710 (ILACO B.V. 1981 and Burton 1978). For bringing the raw food items into edible form, conversion has been done at 60 per cent for rice and 90 per cent for other crops (Asian Development Bank 1982).

The linkages among the different components of the farming system and contribution of each component to others and vice-versa are shown in Tables 5, 6, and 7.

Table 5: Matrix Showing Linkages among Different Components of the Farming System at the Naubise Site (Per Household Averages per Annum)

Production Sectors	Consumption Sections: Crops	Livestock	Forests & Pastures	Household	Market
Crops	Seeds: - Cereals (74 kg) - Oilseeds (1 kg) - S. Cane (162 kg) Compost Materials (1820 kg)	Feeds: (TDN 2288 kg) - Tree Fodder (497 kg) - Grass Fodder (4275 kg) - Dry Roughages (2883 kg) - Concentrates (275 kg) Bedding Materials (532 kg)	-	Food: (4744830 cal.) - Cereals (1662 kg) - Oilseeds (8 kg) - Potato (80 kg) - S. Cane (24 kg) - Vegetables (150 kg) - Fruits (291 kg) Fuel: - Fuelwood (2091 kg) - Crop Residue (708 kg) Roofing Materials (69 kg) Cash (Rs 14783)	Sale: - Cereals (373 kg) - Oilseeds (20 kg) - Potato (96 kg) - S. Cane (410 kg) - Fruits (356 kg) - Vegetables (2741 kg) Wage: - Cereals (179 kg)
Livestock	Fresh Manure (12811 kg) Power (98 ad)	-	Fresh Manure (486 kg)	Food: (338350 cal.) - Milk (335 l.) Cash (Rs 1107)	Sale: - Milk (72 l.) - Live animals (Rs 682)
Forests & Pastures	Compost Materials (426 kg)	Grazing (298 hrs) Bedding Materials (650 kg)	-	-	-
Household	Labour (270 md)	Labour (244 md)	-	-	Labour (230 md)[1] Cash (Rs 17706)[2]
Market	Credit (Rs 2093) Seeds: - Cereals (8 kg) - Potato (29 kg) - Vegetables (Rs 183) Fertilizers (340 kg) Pesticides (Rs 351) Labour (71 md) Power (34 ad)	Credit (Rs 1300) Feeds: (TDN 11 kg) - Concentrates (12 kg) - Others (Rs 613) Animal Purchase (Rs 1301) Other Inputs (Rs 662)	-	Credit (Rs 2425) Cash: (Rs 5421)[3] Food: (282000 cal.) - Cereals (127 kg) - Vegetables (9 kg) - Meat (5 kg) Consumer goods and Services (Rs 9355)	-

Note: ad = Animal-days; and md = Mandays
1 Off-farm employment
2 Includes all cash expenses
3 Off-farm income.

Table 6: Matrix Showing Linkages among Different Components of the Farming System at the Dhuskun Site (Per Household Averages per Annum)

Production Sectors	Consumption Sections: Crops	Livestock	Forests & Pastures	Household	Market
Crops	Seeds: - Cereals (34 kg) - Oilseeds (0.1 kg) Compost Materials (1820 kg)	Feeds: (TDN 1435 kg) - Tree Fodder (100 kg) - Grass Fodder (3392 kg) - Dry Roughages (1778 kg) - Concentrates (51 kg)	-	Food: (3077780 cal.) - Cereals (1049 kg) - Oilseeds (2 kg) Fuel: - Crop Residue - (72 kg) - Cash (Rs 63)	Sale: - Cereals (61 kg) - Oilseeds (3 kg) Wage: - Cereals (19 kg)
Livestock	Fresh Manure (8119 kg) Power (98 ad)	-	Fresh Manure (779 kg)	Food: (28280 cal.) - Milk (28 l.) - Cash (Rs 6307)	Sale: - Live Animals (Rs 63)
Forests & Pastures	Compost Materials (320 kg)	Feeds: (TDN 313 kg)[1] - Tree Fodder (61 kg) - Grass Fodder (2219 kg) - Grazing (686 hrs) Bedding Materials (757 kg)	-	Fuelwood (2977 kg)	-
Household	Labour (161 md)	Labour (265 md)	-	-	Labour (94 md)[2] Cash (Rs 3893)[3]
Market	Credit (Rs 145) Cereal Seeds (3 kg) Fertilizers (33 kg) Labour (3 md)	Credit (Rs 380) Feeds: (TDN 11 kg) - Concentrates (13 kg) Animal Purchase (Rs 52) Other Inputs (Rs 52)	-	Credit (Rs 591) Cash: (Rs 2569)[4] Food: (129600 cal.) - Cereals (60 kg) Consumer Goods and Services (Rs 3279)	-

Note: ad = Animal-days; and md = Mandays
1 Does not include feeds from grazing.
2 Off-farm employment.
3 Includes all cash expenses.
4 Off-farm income

Table 7: Matrix Showing Linkages among Different Components of the Farming System at the Yelung Site (Per Household Averages per Annum)

Production Sectors	Consumption Sections: Crops	Livestock	Forests & Pastures	Household	Market
Crops	Seeds: - Cereals (17 kg) - Potato (68 kg) Compost Materials (48 kg)	Feeds: (TDN 645 kg) - Tree Fodder (187 kg) - Grass Fodder (2568 kg) - Dry Roughages (510 kg) - Concentrates (9 kg)	-	Food: (1055060 cal.) - Cereals (282 kg) - Potato (249 kg) Fuel: - Fuelwood (43 kg) - (16 kg) Cash (Rs 100)	Sale: - Potato (31 kg)
Livestock	Fresh Manure (10142 kg) Power (98 ad)	-	Fresh Manure (16531 kg)	Food: (156550 cal.) - Milk (155 l.) Cash (Rs 2590)	Sale: - Milk (417 l.) - Live Animals (Rs 682)
Forests & Pastures	Compost Materials (548 kg)	Feeds: (TDN 1143 kg)[1] - Trees Fodder (5202 kg) - Grass Fodder (987 kg) - Grazing (2018 hrs) Bedding Materials (797 kg)	-	Fuelwood (2782 kg)	-
Household	Labour (66 md)	Labour (777 md)	-	-	Labour (126 md)[2] Cash (Rs 9954)[3]
Market	-	Credit (Rs 3034) Feeds: (TDN 33 kg) - Concentrates (39 kg) - Others (Rs 198) Animal Purchase (Rs 2955) Other Inputs (Rs 25)	-	Credit (Rs 1110) Cash: (Rs 4691)[4] Food: (773220 cal.) - Cereals (355 kg) - Vegetables (7 kg) - Meat (4 kg) Consumer Goods and Services (Rs 4637)	-

Note: ad = Animal-days; and md = Mandays
1 Does not include feeds from grazing.
2 Off-farm employment.
3 Includes all cash expenses.
4 Off-farm income

Crops and Livestock

There exists a complementary relationship between crops and livestock in the existing farming systems in the hills and mountains. Crops provide feeds and sometimes bedding materials as well to livestock, and in return receive draught power and manures from livestock.

Livestock feeds supplied by crops mostly consist of roughages, such as crop by-products (straw and stover), grass and tree fodder from farmlands, and partly of concentrates such as cereal grains. Of the average annual TDN (stall-fed) consumption by livestock, crops and fodder from farmlands together supply almost 100 per cent at Naubise, about 82 per cent at Dhuskun, and only 35 per cent at Yelung. The contribution of crop by-products alone to livestock feed is as high as 60 per cent at Naubise, compared to 52 per cent at Dhuskun, and only 14 per cent at Yelung. Similarly, cereal grains produced on the farm account for about 10 per cent of the feed supply at Naubise, three per cent at Dhuskun, and less than one per cent at Yelung. Larger farm sizes, higher land productivity, and lack of feed supply from off-farm resources may be the reasons for the larger proportion of livestock feed supply from farm resources at Naubise. The survey revealed that crop by-products are increasingly being used as livestock feed due to reduction in feed supply from non-farm sources, particularly forests and pastures.

Livestock provides draught power and manure to crops. Cultivation of land with the use of animal power and maintenance of soil fertility through the use of farmyard manure (mostly comprised of animal dung), have been age-old practices in Nepalese agriculture. In the hills and mountains, animal power is mostly used in land preparation for various crops. Given the farm sizes, cropping intensities, and the cropping patterns, the average per household use of animal power in crop production is estimated to be 132 animal-days at Naubise, 56 animal-days at Dhuskun, and 24 animal-days at Yelung per annum. Farm animals supply all the power required for crop cultivation at Dhuskun and Yelung and about 74 per cent at Naubise. Crop production is solely dependent on manures for the supply of plant nutrients at Yelung and almost the same is the case at Dhuskun. However, at Naubise, chemical fertilizers also constitute an important source of plant nutrients in addition to manures. The average annual supply of livestock manure (fresh dung) per household for crop production is estimated to be 12,099 kg at Naubise, 7,668 at Dhuskun, and 9,579 kg at Yelung. Thus, animal dung accounts for 83, 86, and 87 per cent of the total available raw materials for compost preparation at the three sites respectively.

Crops and Forestry

Forests directly influence crop production by supplying compost materials and indirectly by supporting farm animals which provide manures and draught required for crop production. In addition, forests, which are usually located on upper slopes, provide protection to crop lands against landslides and soil erosion. Forests are the principle source of fallen, dry leaf-litter and lopped, green foliage of trees and herbaceous species which are used for animal bedding and composting. Forest biomass, when mixed with animal excreta, yields organic compost manure which forms the principle source of soil nutrients for hill agricultural land.

The average annual collection of forest litter per hectare of cultivated land is estimated to be about 439 kg at Naubise, 593 kg at Dhuskun, and 1,957 kg at Yelung. In addition, bedding materials collected for livestock also ultimately go to compost. Thus, leaf-litter and bedding materials, collected from forest together account for about 7, 12, and 12 per cent of the total available raw materials for composting at the three sites respectively. Considering the quantity of compost materials derived from forests, the Yelung Site seems to have the strongest crop-forestry linkages among the three sites. It is worth noting that crop-forestry linkages are one-way at all the sites, i.e., only crops benefiting from forests and not vice-versa. Khadka et al. (1984) have estimated that about 50 per cent of litter production is removed annually from some forests in the Nepalese mid-hills. This seriously interrupts nutrient cycling within the forest.

Livestock and Forestry/Pastures

In general, forests and pastures are more closely linked with livestock than with any other component of the mountain farming systems. The number of livestock to be kept per household in the hills and mountains is mainly determined by the available forest and grazing lands in the area. Forests and pastures provide feed and bedding materials to livestock and, in return, receive manure from grazing livestock.

The quantity of feed supplied by forests is not only determined by the area of available forest lands but also by the availability of fodder trees in the forest. While green grasses and tree fodder from forests are usually collected and stall-fed to livestock, ruminants are directly grazed on pastures. Forests are estimated to supply about 128 and 164 kg of TDN per LSU annually at Dhuskun and Yelung respectively. The contribution of forests to the annual TDN (stall-fed) consumption by livestock are estimated to be 18 and 63 per cent at the two sites respectively. Livestock feed obtained from forests were mostly comprised of grasses at Dhuskun and tree fodder at Yelung. Forest contributions to livestock feed is nil at Naubise where no mature forest exists nearby. Farm animals also get feed from the forests and pastures through grazing. Among the three sites, grazing is most widely practiced at Yelung where abundant forests and pastures are available. Besides feed, forests also supply bedding materials to livestock. The annual quantity of bedding materials derived from forests ranges from about 177 kg per LSU at Naubise to 309 kg per LSU at Dhuskun.

Farm animals, in return, provide manure to forests and pastures while grazing. The annual quantities of manure (fresh dung) contributed by livestock to forests and pastures are estimated to be 486 kg at Naubise, 779 kg at Dhuskun, and 16,531 kg at Yelung. At the Yelung Site, all the manure produced by *Chauries* goes to the forest and grazing lands because these animals are never kept on the farm.

Linkages with the Farming Households

The farming household is linked with all the components and plays the key role in the overall operation of the farming system. Though the householders as managers and decision-makers make a number of contributions to the farming system, it is only the human labour, contributed by the households to the different components of the farming system, which can be easily quantified. The average per annum per household family labour inputs, into the production of crops and livestock respectively, are estimated to be 270 and 244 mandays at Naubise, 161 and 265 mandays at Dhuskun, and 66 and 777 mandays at Yelung. The household labour contribution to forestry and pastures was not reported at any site. For the protection of forests, watchmen were reported to have been hired by the Government at all the study sites.

The households obtain food, fuel, and cash from crop, livestock, and forestry components of the farming system. The average food consumption per capita per day is estimated to be 2,062 calories at Naubise, 1,733 calories at Dhuskun, and 989 calories at Yelung. The contributions of crops and livestock respectively, to household food consumption, are estimated at 89 and 6 per cent at Naubise, 95 and 1 per cent at Dhuskun, and 53 and 8 per cent at Yelung. The balance of food for household consumption is obtained from the market at all the study sites. Though cereals constitute the major source of food at all the study sites, fruits and vegetables account for about 4 per cent of the calorie intake at Naubise and potatoes supply about 9 per cent of the calorie intake at Yelung.

The average per capita fuelwood consumption per annum is estimated to be about 393 kg at Naubise, 601 kg at Dhuskun, and 517 kg at Yelung. Crop by-products and farm trees supply all the fuel consumed by the households at Naubise. In contrast, households at Dhuskun and Yelung obtain almost all the fuel for household consumption from forests. The quantity of crop by-products used as fuel is as high as 708 kg per household at Naubise compared to 72 kg at Dhuskun, and 16 kg at Yelung. Farmers at the Naubise Site are compelled to use crop by-products as fuel in the absence of fuelwood supply from off-farm sources.

Crops and livestock are also important sources of cash income to the farming households. Of the average annual cash income per household, crops and livestock respectively account for 69 and 5 per cent at Naubise, 8 and 2 per cent at Dhuskun, and 1 and 35 per cent at Yelung.

While the farming households maintain two-way linkages with crops and livestock, their linkages with forests are rather one-way.

Linkages with the Market

Crops, livestock, and, of course, the farming households are found to have linkages of various degrees with the market. Crop production at the Naubise Site is dependent to a large extent on the market, not only for the procurement of production inputs, particularly chemical fertilizers, vegetable seeds, pesticides, and credits, but also for the disposal of crop outputs such as cereals, fruits, and vegetables. The crop-market linkages are rather weak at the Dhuskun Site and almost non-existent at Yelung. The development of strong crop-market linkages at the Naubise Site can be attributed mainly to relatively larger farm sizes; the irrigation facilities are better and accessibility to well-developed markets is easier at this site compared to the other two sites.

However, the livestock component is found to be most closely linked with the market at the Yelung Site where livestock production is considered to be the major agricultural enterprise. The Cherdum Cheese Factory, Jiri, and its sub-branches at and around the Yelung Site are believed to have played an important role in the development of such a strong livestock-market linkage at this site. The livestock-market linkages are pronounced at Naubise also, but are very weak at Dhuskun.

While the farming households are almost solely dependent on the market for consumer goods and services at all the study sites, the market's role as a supplier of food is most pronounced at Yelung where about 39 per cent of the annual food consumption by the households is obtained from the market. The employment opportunities provided by the market are the highest at Naubise followed by Yelung and Dhuskun. The average number of mandays per household, employed annually in off-farm activities, ranges from 94 at Dhuskun to 230 at Naubise. The major sources of off-farm employment are services, business, and wage labouring in agricultural and construction works at Naubise; services and wage labouring in agriculture at Dhuskun; and tourism (portering and working as trekking guides) at Yelung which lies on the trekking route to Mt. Everest. The amount of off-farm income per household is lower at Dhuskun compared to the same at Naubise and Yelung. However, the share of off-farm income to the total cash income per household at Dhuskun is as high as 90 per cent compared to 64 per cent at Yelung and 26 per cent at Naubise.

If the overall linkages with the market are considered, market forces seem to have the strongest influence on the farming system at Naubise among the three study sites.

IV. CONCLUSIONS AND IMPLICATIONS

The findings of the case studies at the three study sites, namely Naubise in the low hills, Dhuskun in the middle hills, and Yelung in the high hills indicate that the Yelung Site is relatively better-off in forest and grazing resources compared to the other two sites and, consequently, the size of livestock holding is also much higher at the former site. However, the per capita availability of cultivated land is relatively higher at Naubise and Dhuskun. Thus, pressure on cultivated land is found to be the highest at Yelung and the lowest at Naubise. The Naubise Site is also better privileged in terms of accessibility and availability of inputs, services, and irrigation and market facilities compared to the other two sites. Agriculture seems to have significantly transformed at Naubise where the use of modern inputs in farming is reported to be quite high. Agricultural practices are mostly traditional at the other two sites with very little use of modern inputs in farming. As a result, the productivities of both crops and livestock are higher at Naubise compared to those at the other two sites.

The analysis of the linkages among the different components of the farming systems at the three study sites reveals the following:

- crop-livestock linkages are almost equally strong at all the study sites;
- crop-forestry linkages are strongest at Yelung, followed by Dhuskun and Naubise;
- livestock-forestry linkages are stronger at Yelung than those at Dhuskun and very weak at Naubise;
- household-forestry linkages are strong at Dhuskun and Yelung and non-existent at Naubise;
- crop-livestock-household linkages are strong at all the study sites; and
- linkages with the market are the strongest at Naubise, followed by Yelung and Dhuskun.

The above findings can be generalized to imply that farming-forestry-livestock linkages are strong in areas which are relatively better-off in forest resources and where there is little intervention of market forces and little transformation has taken place in agriculture. In contrast, these linkages are weak in areas where forest resources are scarce and there is a strong influence of market forces on farming, and, as a result, agriculture has significantly transformed. In such areas, most of the material inputs previously derived from forests have been replaced partly by market products and partly by farm products. Changes in farming practices such as the reduced size of livestock-holdings, changes in herd composition of livestock, increased stall-feeding practices, increased use of chemical fertilizers, and increased use of crop by-products as livestock feed and fuel for cooking have also helped reduce the dependency on forest resources.

Discussions with the elderly and knowledgeable farmers indicated that the overall linkages with forestry have become weaker over time, not only due to gradual reduction in forest areas but also due to deterioration in the conditions of forests with adverse effects on environment and the productivity of the farming system, particularly in those areas where market forces have little influence on farming. Fodder trees are reportedly disappearing from forests and no efforts have been made to include these trees in new plantations established by the Government. While the

adverse effects of dwindling forest resources on farm productivity have been countered by increased use of market inputs in accessible areas, the environmental problems are serious everywhere. The twin objectives of increasing agricultural productivity and protecting the environment seem to be rather conflicting if the existing farming-forestry-livestock linkages are considered in the context of dwindling forest resources. While strong linkages are essential for increasing agricultural productivity, the same may lead to forest degradation and environmental deterioration. In such a situation, development efforts and strategies have to be balanced in such a way that both the objectives of increasing productivity and improving environment are met.

For the protection and improvement of environment, the existing pressures on forests for various products have to be eased on the one hand and forestry development activities have to be accelerated on the other. This may, in the short-run, lead to increased shortages of material inputs supplied by forests to farming. In order to balance these shortages, improvements are essential not only in market facilities but also in farming practices. While increased input supply from the market will partly make up for the shortages, increased plantation of fodder and fuelwood trees on the farmland, reduction in sizes of livestock holdings by replacing poor breeds with a smaller number of more productive breeds, increased stall-feeding practices, improvements in irrigation facilities, efficient use of compost through improvements in preparation and application methods, increased use of chemical fertilizers and improved seeds, increased multiple cropping practices, and efficient use of fuelwood through adoption of improved stoves for cooking will not only augment agricultural productivity but also improve environmental conditions by reducing the pressure on forest resources. Forestry development programmes should be geared towards fulfilling the needs of local people rather than merely achieving the targets. In the context of increased shortages of livestock feed in the hills and mountains, adequate priority needs to be accorded to fodder trees in new plantations. Since the long-term success of any development programme depends to a large extent on the participation of local people, this aspect needs to be adequately addressed while initiating rural development programmes in general and forestry development programmes in particular.

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