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 361) 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.