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The middle hill region* of Nepal is an area where population pressure and a deteriorating resource base make most imperative an effort to improve agricultural productivity. The government of Nepal has designated increased horticultural production as one phase of a major thrust designed to better the income, employment and nutrition of the people of the Nepalese hills (Nepal, 1972, p. 132). It is also hoped that partial specialization in fruit and vegetable production within the hills will allow for increased trade with the plains area of the country, which has a superior land base and hence a comparative advantage in cereal production. Despite this interest in horticultural development, no micro-level survey of the actual and potential contribution to well-being made by fruit and vegetable production has been undertaken. The present study of Nuwakot district measures the extent to which production and consumption of horticultural crops contribute to the income, employment and nutrition of hill cultivators. It also projects the impact on these three indices of increasing levels of horticultural production under a variety of conditions. The study area lies within the watershed of the Trisuli River and is representative of the geographic, social and economic conditions of Nepal's middle hills.

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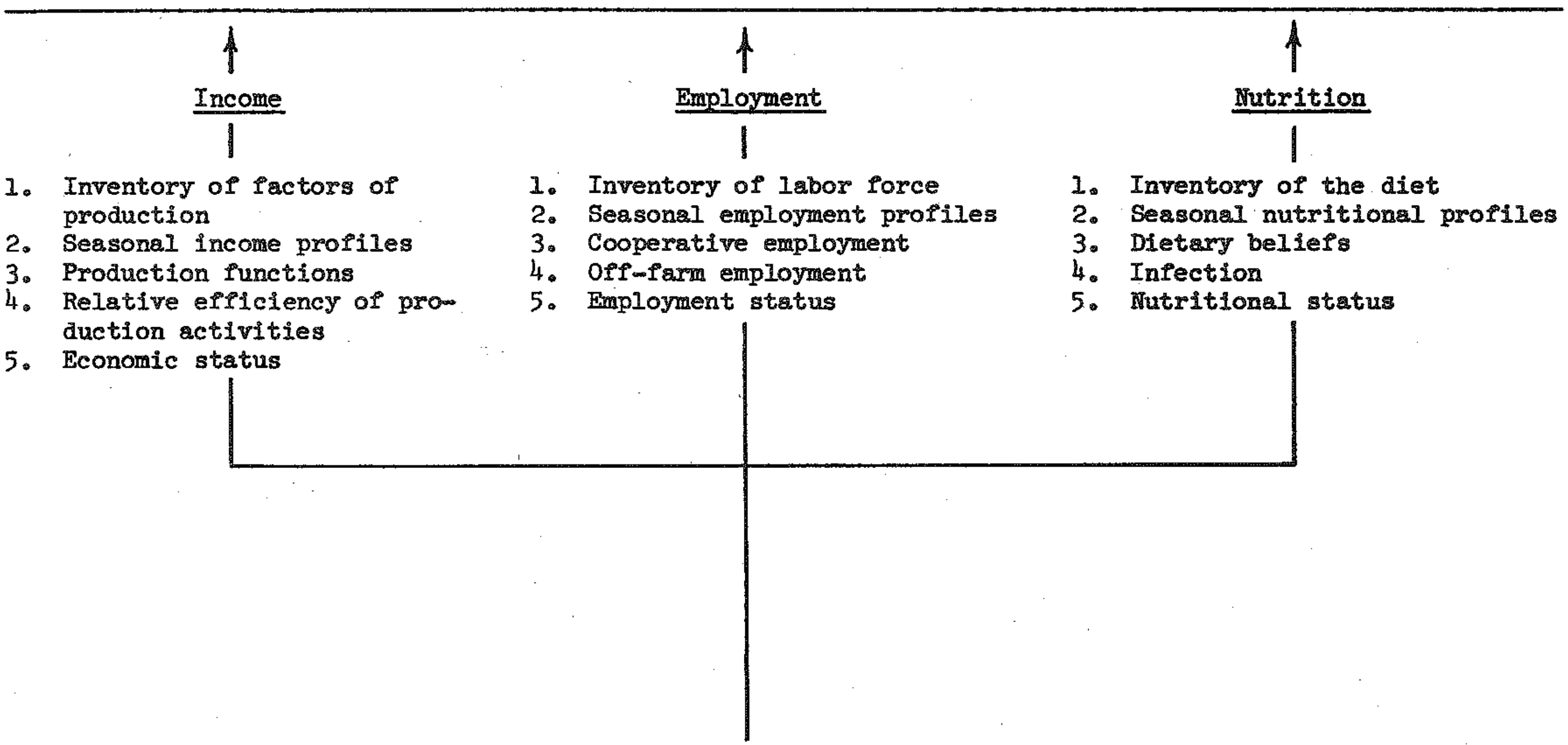
* Areas of between 500 and 3,000 meters lying in the foothills of the Himalayas.

THEORETICAL FRAMEWORK

The Government of Nepal is interested in improving the standard of living of the people of the middle hills. It is hypothesized that this can be achieved through intensified horticultural production. Although there are undoubtedly other components, let us posit that the three most important elements which make up the standard of living are income, employment and nutrition. These elements are not only significant individually, but also contribute to the holistic notion of well-being through their interactions. Therefore, we shall view present and future levels of the standard of living as if they were a trident consisting of the prongs of income, employment and nutrition. This image is especially apt since the name of the Trisuli River means "trident-like" and is derived from the Hindu story in which the God Shiva hurled his trident into the side of a mountain creating the triple source of the river. The geographic, and to some degree, the economic and social characteristics which dominate the study area are substantially influenced by the fertile valleys and steep hills dissected by the Trisuli and its tributaries. Thus, the physical river and the conceptual standard of living tridents are strongly interrelated.

Figure 1 depicts the conceptual trident, the left prong being income, the center employment and the right nutrition. Listed as 1 through 4 under each are important sub-indices of well-being which determine number 5, or the status represented by the prong in question. Each of the three prongs is critical in development theory. The role of income in national development stresses the importance of growth in aggregate income and equalization of income distribution. Additional employment may improve income distribution as well as overall income growth. Nutrition

Figure 1: The Well-Being Trident



has often been overlooked in economic treatises, although it can directly affect productivity. Increases in well-being through nutrition programs provide a quickly apparent and appreciated indication of government concern.

This study is an inquiry into the extent to which the farmers of the middle hill zone are able and willing to specialize more completely in horticultural production. It also examines the likely effects on their patterns of production, employment and diet should they move in the direction of this specialization. The middle hill region was chosen because it is there that population pressure and resultant deterioration of the land base are the most pronounced.

OBJECTIVES

The objectives of the study will be to:

1) describe present production activities in six purposefully sampled villages of the Nepalese hills. Particular emphasis will be given to income, employment and nutrition;

2) estimate the contribution of horticulture to income, employment and nutrition in these villages;

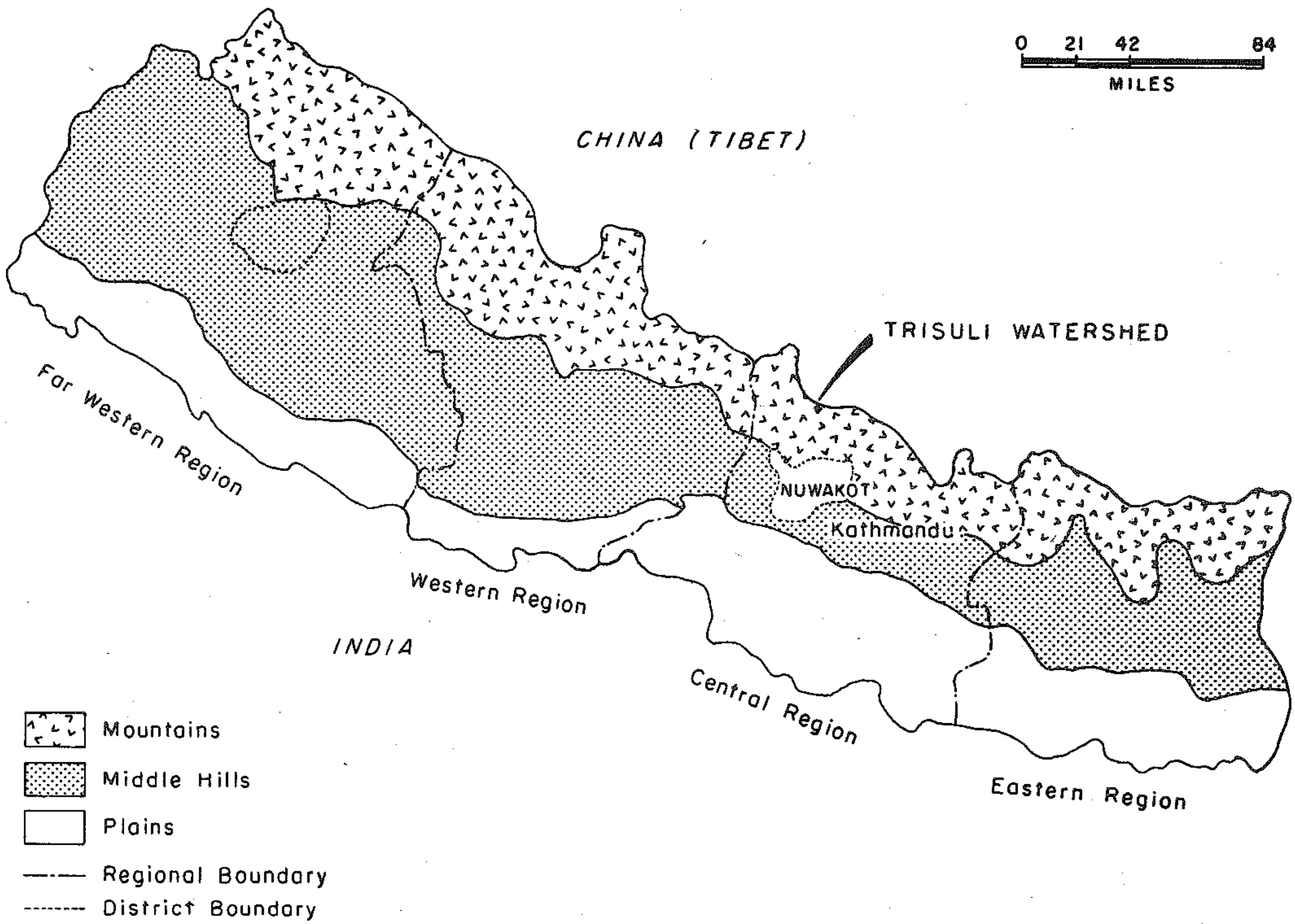
3) compute the optimal enterprise mix if increased emphasis is given to horticulture. This will be done through linear programming analysis of four representative farms;

4) compute the levels of income, employment and nutrition associated with the optimal production mixes.

THE STUDY AREA

Map I shows the country of Nepal with the various elevational zones delineated. Nuwakot district contains a land area of 5,768 square

MAP I. NEPAL AND THE TRISULI WATERSHED



kilometers with a dense population of 1,286 people per square kilometer (Nepal, 1974). The District's rough topography contains elevational differences of almost three thousand meters with slopes of up to 80 percent. Precipitation ranges from 1,000 mm at lower elevations to 3,000 mm at higher elevations. The heavy rainfall, steep slopes, powerful winds and intensive land use combine to create severe erosional problems at higher elevations. Nuwakot district typifies the seasonal rainfall pattern of a well developed monsoon area. At lower elevations, extremely heavy rainfall is concentrated during the monsoon season. The dry period is characterized by torrid heat with little or no rainfall. At the higher elevations there is considerable precipitation between March and August. Winters are bitterly cold, but snowfall is light and erratic. As a result of the action of natural forces on the topography, a wide diversity of soil and land capability types has developed. Soils are of generally good quality with medium levels of organic matter and other nutrients, despite moderately low pH levels (UNDP, 1975).

Six villages were carefully selected in order to capture the full range of climate, soil types, isolation from market centers and social and ethnic characteristics in the study area. The first step was to delineate three separate regions called land bases. These areas were chosen primarily on the basis of isolation or distance in walking time to the major trading center. Each land base was also defined so that it encompassed a wide range of altitudinal differences, allowing the researcher to simultaneously examine the influence of market isolation and factors related to elevational variability. The entire study area, which included the three land bases, was chosen to be small enough to be surveyed by the researcher and a team of seven enumerators engaged to gather data.

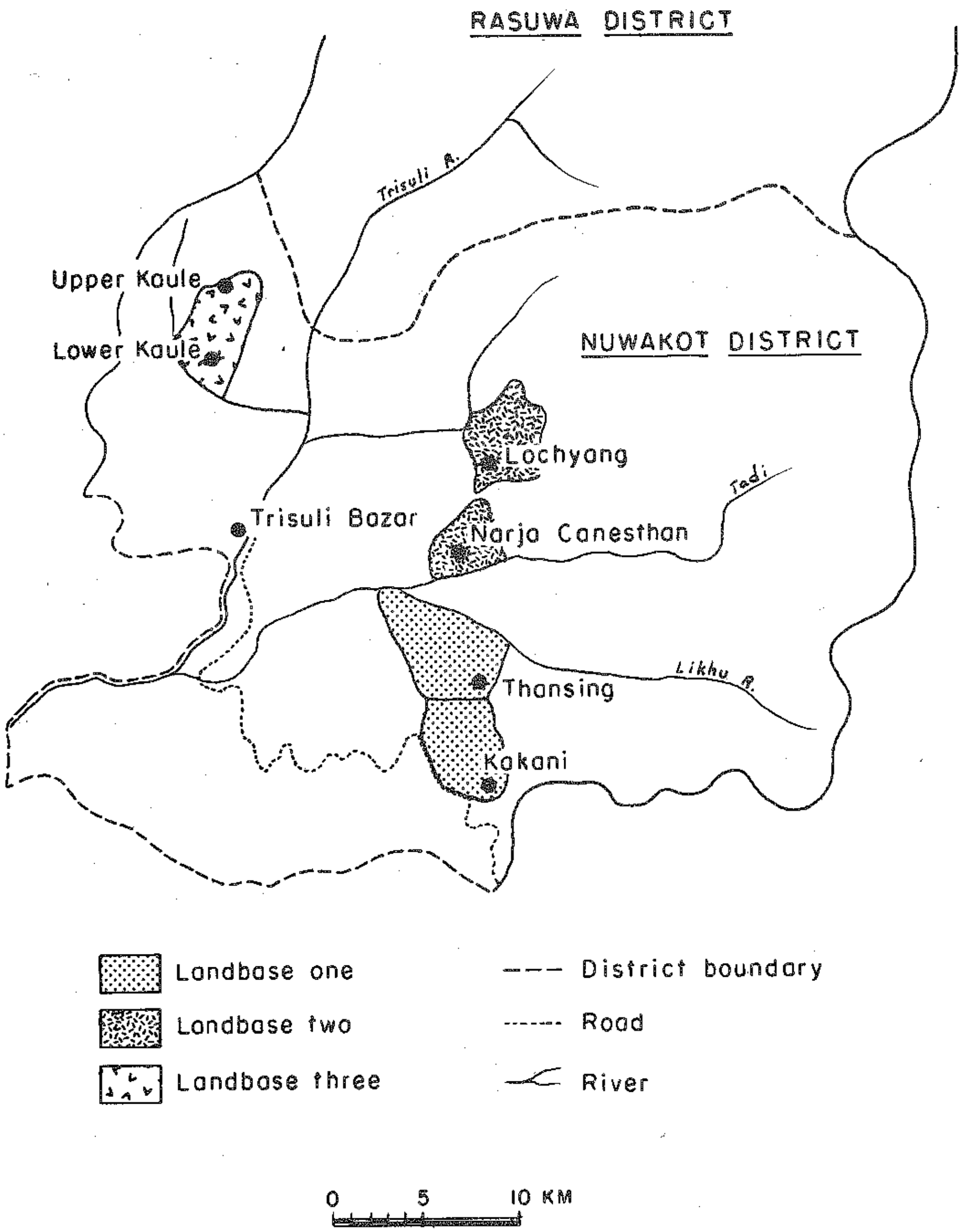
Each land base included an altitudinal range of from approximately 500 to 2,000 meters. Higher elevations were not sampled since they contained limited possibilities for horticultural production. The three land bases were explored extensively on foot and characteristics were noted on a contour map. Two villages in each land base were chosen for study, primarily on the basis of altitude. It appeared that there were distinct differences between villages situated above and below a dividing line at 1,200 meters of elevation. One village was chosen to be well above this altitude and the other well below it. These six villages allowed the researchers to investigate those agricultural practices and potentials for improved horticultural production relating to isolation from market and to altitude.

Map II shows the study area with the six villages. The three land bases and their villages are as follows:

Land Base One -- Thansing and Kakani: This region lies on the Kathmandu-Trisuli Road about eighteen miles, or half a day's walk, from Kathmandu. The area is three to four hours from Trisuli. Thansing is the low village and Kakani the high one.

Land Base Two -- Narja Ganesthan and Lachyang: Although it lies directly north of land base one, this region is a one and one-half day walk from Kathmandu due to the natural barrier formed by two rivers. The area is three to five hours from Trisuli on foot, but the inhabitants prefer to make the much longer walk to Kathmandu because of better price relationships there. Narja Ganesthan is at the lower elevation and Lachyang at the higher.

MAP II. THREE LANDBASES IN NUWAKOT DISTRICT



Land Base Three -- Lower Kaule and Upper Kaule: This region is a three to five hour walk from Trisuli but two and one-half days on foot from Kathmandu. The added day's walk to Kathmandu is sufficient to cause most of the people of this land base to trade in Trisuli.

A comparison between the two villages in each land base makes clear the economic and ethnographic reasons for choosing such pairs. The upper villages are entirely of the Tamang caste. The inhabitants are Mongolian in appearance, live in cramped, ill-lighted homes, speak a Tibeto-Burman language, and wear rough tunics rather than the Hindu lungis and loincloths. The villages below the 1,200 meter level are inhabited primarily by higher caste Hindus, notably Brahmins and Chhetris. The people are Aryan in appearance, live in more substantial dwellings, wear Hindu dress, and speak an Indo-Aryan language. These differences served as a basis for the 1,200 meter elevational division. This division separates the poorer from the richer, the less educated from those with more education, the politically uninfluential from those with political power, the poor soil and water scarcity from the good soil and plentiful water, the maize-millet area from the rice-wheat area, and the temperate zone from the tropical zone. The area straddling the 1,200 meter line served as a subtropical interstice. The 1,200 meter elevational belt is where the wealthy people of both Tamang and Hindu origin tend to dwell. This is because the climate in the subtropical zone is uniform and mild.

SURVEY PROCEDURE

Two types of survey were used to analyze differences in the three regions. The first or general survey involved interviews with 200 farmers in each land base. Approximately 100 farm households were selected from each higher elevation village and 100 from each low-lying village. The entire general survey thus involved a sample of 600 households. These farm families were interviewed twice during the 1973-74 crop season. The interviews were timed to correspond with a period of peak farming activity and one of slack labor demand. The general survey sought to generate summary statistics relative to the present pattern of production, consumption, trade, and enterprise combinations in the entire sample area. These statistics provide a benchmark for a description of current farming practices and activities of the people residing in the middle hills of Nepal.

From the summary statistics of the general survey, forty households were selected as being representative of a wide range of characteristics relating to the physical environment, farm size, ethnography and degree of isolation. These forty farms were visited daily for a full cropping year by enumerators who gathered a vast array of information relating to all facets of agricultural, household and off-farm activities for the year. The general survey provided an overview of 600 farm households of Nuwakot district, while the daily survey provided an in-depth look at the activities of farm families thought to be representative of middle hill farmers.

RESULTS OF THE GENERAL SURVEY

The analysis of the general survey material will proceed in two steps. First, summary statistics are used to indicate the more important features of the 600 sample households. Second, regression analysis identifies significant causal linkages between explanatory variables and income, employment and nutrition in the sample.

DESCRIPTIVE STATISTICS

Table 1 shows the contrast in farm size, land use and employment in the six study villages. In the following discussion of village characteristics, two points should be kept in mind. First, the description emphasizes differences between land bases, where variability is mainly a function of distance from markets, power sources and transportation. Second, the villages are contrasted as to high (1,200 meters) and low, emphasizing differences attributable to elevation.

Several important distinctions based on proximity to transportation and market centers may be drawn from Table 1. If Kathmandu is presumed to be the vortex around which employment, off-farm sales, and purchases by farm families are centered, the villages can be ranked as follows: land base one is the least isolated, there is an intermediate degree of isolation in land base two and the villages of the third land base are the most remote. It should be kept in mind that in this section of the analysis, household data for both high and low elevation villages have been combined.

Farm size decreases significantly with distance from market. In land base one, average farm size is 0.74 hectare, while in land base three, farm size is only 0.40 hectare. It is well to pause and contemplate the true meaning of these very small farms. For example, in the remote land base area, average crop land available per household member is 0.07 hectare -- clearly one of the most poorly endowed areas in the world. The cropping index* adds further credence to land scarcity, increasing from 1.56 in land base one to 1.82 in land base three.

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* The cropping index is defined in this study as the number of crop seasons cultivated per farm per year.

Table 1. CHARACTERISTICS OF SIX SAMPLE VILLAGES, NUWAKOT DISTRICT, NEPAL

	Land Base One		Land Base Two		Land Base Three		Land Base One	Land Base Two	Land Base Three	Low Elevation	High Elevation
	Low	High	Low	High	Low	High					
Average Farm Size (hectares)											
Owned	0.618	0.337	0.354	0.353	0.236	0.183	0.478	0.354	0.210	0.403	0.291
Rented	0.309	0.207	0.385	0.092	0.331	0.044	0.258	0.239	0.188	0.342	0.114
Farmed	0.927	0.544	0.739	0.445	0.567	0.227	0.736	0.592	0.397	0.744	0.405
Land Devoted To: (percent)											
Cereals	77	80	81	79	90	84	79	80	87	83	81
Horticulture	23	20	19	21	10	16	21	20	13	17	19
Cropping Index	1.50	1.61	2.09	1.26	2.40	1.24	1.56	1.68	1.82	2.00	1.37
Chemical Fertilizer Used (kilograms)	47.03	33.17	13.00	0.62	1.97	0.91	40.10	6.81	1.44	20.67	11.57
Family Labor (days)											
On Farm	890.71	672.59	699.32	715.79	592.88	389.10	781.65	707.56	490.99	727.64	592.49
Off Farm	78.11	149.79	61.12	72.80	89.16	126.52	113.95	66.96	107.84	76.13	116.37
Total (man-years)*	2.58	2.19	2.03	2.10	1.82	1.37	2.39	2.07	1.60	2.14	1.89
Household Size (persons)	6.13	5.98	5.83	5.11	5.65	5.27	6.06	5.47	5.46	5.87	5.45

*Based on 8 man-hours per day and 3,000 man-hours per year.

SOURCE: Survey Data, Nuwakot District, September 1973-May 1974.

In all villages cereals are the staple crop and primary source of calories. In low-lying villages the main cereal is rice, while at higher elevations maize and millet predominate. Again we see a continuum of increasing subsistence as villages become more and more remote. In land base one, 79 percent of the arable acreage is devoted to cereals, while in land base three, 87 percent of the meager cropland must be devoted to grains. If nutritional quality of the diet is to be improved in a subsistence society, more hectarage must be devoted to fruit, vegetables and livestock products. The two villages in land base one devoted 21 percent of their crop area to the production of fruit and vegetables, while in land base three only 13 percent could be allocated to horticultural production.* Although not shown in the table, there is a slight tendency for more livestock to be produced in the remote villages, particularly at higher elevations.

Purchased inputs provide a good indication of the limitations imposed on agriculture by distance from markets or roads suitable for mechanized vehicles. In land base one, farmers purchased an average of 40.1 kilograms of chemical fertilizer per farm, while in land base two the level dropped to 6.8 kilograms and in land base three use fell to a meager 1.4 kilograms per farm. While not recorded in Table 1, data was collected concerning off-farm expenditures in each of the families. Households in land base one spent an average of US $137 per year. In land base two, expenditures were $75, while households in land base three spent only $39 per year for all purchased farm inputs, medicine, clothing and other goods. This is dramatic evidence of the importance of transportation not only in terms of making farm inputs available, but also in providing

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* Pasture land was not considered to be crop land. Consequently, area devoted to cereals plus area in horticultural crops equals total crop area.

farmers and their families with goods which would lead to a higher standard of living. Availability of these goods may be conceived of as a factor which would catalyze change in cultural practices and the adoption of new agricultural techniques.

Several different trends appear when villages are examined according to their elevation rather than distance from Kathmandu. Now we are cutting across land bases with the sort factor altitude. Even a cursory look at Table 1 reveals that villages lying below 1,200 meters have higher statistics in every category -- greater farm size, more land devoted to cereal production, higher cropping index, more chemical fertilizer used and more days worked by the family on the farm. Family size itself is greater on the lower elevation farms. But a cursory glance does not tell the entire story.

The key to the figures is farm size. On the average, farmers in the three villages at the lower elevation work almost 50 percent more land than do their counterparts living above 1,200 meters. In addition, half of the land at lower altitudes is irrigable, compared with only a third in the upper villages. This results in greater productivity at lower levels. The cropping index is a further indication of the intensive use of land in the lower elevation villages -- 2.0 in the lower villages and 1.4 in the upper.

The proportion of crop land devoted to cereals is very similar in the two sets of villages. The reasons for these high proportions differ. At lower elevations, the grain produced is rice. This is a highly marketable crop and is profitable to produce. If they so desired, farmers in the lower elevation villages could gear themselves to a market economy, raising rice for sale and buying the balance of food requirements.

The upper elevation at which rice can be produced is approximately 1,500 meters. On farms above this elevation the cereal rotations are complex but most center around maize and millet. These are grown for home consumption rather than sale, reflecting the subsistence economy which predominates in villages at higher elevations.

At first glance, it appears that the lower villages are much more intensive users of chemical fertilizers than are their high altitude neighbors, averaging 44 percent more kilograms per farm. Farm size is, however, a confounding factor. When put on the basis of kilograms used per hectare, high and low elevation villages are nearly equal in their use of chemical fertilizers.

Similarly, the figures in Table 1 indicate that families at lower elevations spend many more days working on their farms, but this is related to the greater size of the low-lying farms and to the seasonal nature of the crops grown. Low elevation farmers have a considerably higher cropping index combined with peak labor demands, while on the upper level farms, demands tend to be more even. The small size of higher elevation farms generates lower incomes, forcing more family members to seek seasonal off-farm employment.

The general survey also gathered data on food consumption, knowledge of nutrition, and infant mortality in an effort to determine the nutritional status of households. Standard measures of protein and calorie requirements for well-nourished East Asian people (FAO, 1972 and Aykroyd, 1963) were used to investigate malnutrition in the sample. From the diet of interviewed families, daily consumption of calories and protein were calculated for two periods in the year -- pre- and post-harvest. For each family a quality index was computed by comparing daily consumption with the established requirements. The index for calories and that for protein were averaged to provide a combined calorie-protein figure. For example, if a family's caloric intake was ninety percent of the standard requirements, and its protein consumption was eighty percent, the overall dietary quality index would be 0.85. Except in unusual circumstances, a quality index of 1.00 or above would imply an adequate diet from both a calorie and protein standpoint, although obviously a particularly high intake of calories might offset a shortfall of protein. Surprisingly, the survey indicated higher dietary deficiencies after the harvest, which occurs in November. This is due to the fact that pre-harvest statistics were obtained by interviewing families immediately before the harvest, which is a key festival period in which even families with shortages during other times of the year try to eat as well as possible. Consumption data obtained during a non-festival period probably would have shown different results. Also, families living close to subsistence level apparently tend to store food against future requirements. They may be so adamant in this regard that they do not ingest adequate calories or protein until they feel confident that enough food will be available from the coming harvest. Despite these facts, only one village, Lower Kaule, had what might be described as a severe dietary deficiency -- a dietary quality index of 0.88 -- and that only during part of the year. In general, the figures show no evidence of protein-calorie malnutrition in the study area.

As in most subsistence societies, aggregate statistics may hide important nutritional problems. While no medical examinations were made of infants or pregnant and lactating women, there is evidence that these groups did suffer from nutritional inadequacies. Food taboos and customs rather than an absolute shortage of nutritious food were most frequently the cause. The incidence of infant mortality does indicate the lack of weaning supplements and poor knowledge concerning the nutritional needs of children aged one through five. For example, in Kakani and Upper Kaule, infant mortality exceeded thirty percent during the study period. A number of factors led to this high level of mortality, but there is evidence that poor diet fed to the children, seasonal variation in the diet and inadequate knowledge of nutrition on the part of parents were all contributing factors.

Regression analysis was used to gain valuable insights relative to important relationships among the households in all six villages. Equations were formulated to examine the relationships between selected variables and three significant indicators of household well-being — the aggregate value of farm production, the value of fruit and vegetable production and a measure of health and nutrition.

Several functional forms were experimented with in order to obtain the most statistically valid fit for each of the three parameters to be estimated. The entire array of statistical analysis cannot be presented in a paper this length. To provide the reader with an example of variables used and the resultant correlation coefficients, a linear equation for estimating the aggregate value of farm production is presented below. Similar equations were fitted to estimate the value of horticultural production and nutritional status. For a more complete explanation of both the methodology and results, see Calkins (1976, pp. 99-120).

$$V = -1384.82 + \underset{(155.20)}{740.30}\, LB_3 + \underset{(16.71)}{113.98}\, I + \underset{(28.53)}{216.17}\, UI - \underset{(30.3)}{172.56}\, A + \underset{(0.61)}{1.26}\, HL$$

$$+ \underset{(0.21)}{4.41}\,CL + \underset{(0.21)}{1.24}\,FL + \underset{(0.15)}{0.53}\,E + \underset{(0.52)}{3.59}\,M + \underset{(1.36)}{4.98}\,CF + \underset{(0.19)}{1.01}\,C + \underset{(174.23)}{754.34}\,N$$

$$- \underset{(0.07)}{0.55}\,NL \qquad \bar{R}^2 = 0.77$$

where V = the aggregate value of farm production in rupees.

BB_3 = land base which reflects distance from markets and transportation -- in this particular equation, land base three.

I = irrigated area of paddy.

UI = area of non-irrigated land cultivated.

A = the difference between productivity of non-irrigated land at elevations above and below 1,200 meters.

HL = total number of hired labor days.

CL = total number of days in which cooperative labor worked on the farm.

FL = total number of family labor days devoted to agricultural activities on the farm.

E = differential in labor productivity between workers having less than six years of education and those with more than six.

M = quantity of farmyard manure used.

CF = quantity of chemical fertilizer used.

C = value of total farm capital including tools, farm buildings, and draft animals, but excluding fertilizer.

N = nutritional status of the family, measured at two seasons of the year and averaged.

NL = an interaction term relating nutritional status and labor productivity.

Standard errors are indicated in parentheses under each coefficient. All of the variables are significant at least at the 0.025 level, and with the exception of the interaction term between nutritional status and family labor, all bear the expected signs. Land area is obviously equations, there is one exception to this finding. Radishes provide a very profitable source of income for farmers in the village of Kakani where they can take advantage of excellent transportation and strong demand in the Kathmandu market.

Little chemical fertilizer is applied to vegetables in Nuwakot district and none was used by the sampled farmers on fruit. Farmyard manure was an important input on vegetable products and contributed significantly to the value of their production. Apparently little manure is applied to fruit trees.

Surprisingly, labor is not a significant determinant of income from vegetable production. It may be hypothesized that adequate amounts of labor for planting, weeding, and harvesting are already used on most vegetable plots, and marginal additions of labor above these requirements have a very low or zero payoff. This is not true in the case of fruit, where less labor is used per unit of land. Here the use of increasing quantities of labor, probably for pruning, more careful grading and marketing, does contribute to added income.

The value of fruit and vegetable production as a proportion of total crop income varies markedly with altitude. At lower elevations vegetable production constitutes 13 percent of crop income, while fruit is only six percent. At higher elevations, vegetable production is 29 percent of crop income and fruit is 14 percent. As an indicator of the profitability of horticultural products for the study area as a whole, vegetable production constitutes 18 percent of crop income but only 12 percent of arable land. Similarly, farmers earn significantly more for labor spent on horticultural products than they do on cereals. For example, only about one percent of labor devoted to crops is utilized for fruit production, while fruit generates nearly five percent of total crop income. In the case of cereals, 95 percent of the labor generates only 78 percent of the income. It would appear from both the equations and summary statistics that increased emphasis on fruit and vegetable production would offer substantial improvements in farm income.

Of the households surveyed, more labor was devoted to cereal production per unit of land than to vegetable production. This finding poses an interesting dilemma for policy planners. Increased vegetable production will generate a higher level of income; however, it reduces the utilization of family labor. The analysis does not answer one important question: what would happen if larger amounts of labor were devoted to vegetable production? The authors' observations indicate that vegetable production is considered a residual claimant of labor after requirements for grain production have been met. It is therefore possible that emphasis on vegetable production could lead to a higher level of both employment and income.

In this examination of the nutritional status of hill people of Nepal, it was reasoned that the citizens of Nuwakot, who have extremely limited arable land per capita, might suffer from nutritional problems which would reflect on their labor productivity, morbidity and mortality. Equations were fitted to test two features of health and nutrition. The first dimension tested was the overall quality of the diet, while the second was an examination of whether the diet quality varied appreciably from season to season. Lack of storage facilities, remoteness from markets, inadequate irrigation and a distinct wet-dry climatic regime suggested that the quality of diet might vary markedly across seasons.

General equations which looked at nutritional status on an annual basis were fitted first, but it was recognized that these could mask important seasonal dietary problems.

Of the various formulations tested, including Cobb-Douglas functions, a linear relationship proved to be the most satisfactory. It was found that people who live below 1,200 meters have a better nutritional status than do those who live at higher altitudes. Interestingly, however, higher nutritional intake is associated with being of the Tamang caste,* which suggests that the lack of dietary taboos, particularly concerning buffalo meat and alcohol, makes for unusually high protein-calorie intake in this group. The analysis further shows that increases in livestock owned, and in vegetable land per capita below 1,200 meters tend to improve the quality of the diet. A similar improvement follows from an increment in fruit land per capita at higher elevations. This is in contrast to income findings, where vegetables were found to be more profitable at higher elevations and fruit more profitable at lower altitudes. Diet improvement is also associated with the number of different types of food consumed, notably special festival foods. Finally, income and employment status as measured by the value of land holdings and the number of days worked per year (especially on the farm) are positively correlated with better diet.

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* The reader will recall that Tamang families inhabited the higher elevations. This suggests an inconsistency in the findings. The explanation is that some Tamangs were found at lower elevations, while scattered Hindu households were found at higher elevations. For this reason, it is possible to simultaneously have lower elevation households and Tamang households enjoying a better diet. In one instance, the sort factor is elevation, in the other, caste.

Relative to seasonal fluctuations in dietary quality, econometric analysis indicates that a number of variables influence a family's ability to maintain a nutritious diet throughout the year. Four variables appear to be particularly important -- complexity of the diet, altitude, livestock production and caste differences. Storable roots, tubers and staple cereals provide adequate calories throughout the year. When supplemented with livestock products, fruit, vegetables and poultry, this more complex diet appears to be adequate on a year-round basis.

Altitude importantly affects seasonal food consumption patterns. It is clear that seasonal differentials in dietary quality increase with altitude. Growing seasons are shorter at higher elevations, ruling out perishable fruit and vegetables during the cold winter months. Trade involving an exchange of cereals for horticultural products grown at lower elevations during the winter is a possibility, but the limited availability of land and a very small marketable surplus of grains make this prospect infeasible for most high elevation families. Higher elevation people with no cultural or religious prohibitions against liquor also convert significant quantities of their grain into alcoholic beverages, further reducing prospects for exchange.

People residing at higher elevations do produce a greater quantity of livestock products, adding to their ability to maintain a nutritious diet year-round. When the influence of altitude is eliminated, Tamang people have less seasonal variation in what they eat than do households which are Hindu, reflecting the importance of caste as a determinant of dietary stability.

RESULTS OF THE DAILY SURVEY - LINEAR PROGRAMMING ANALYSES

The second or daily survey involved a 40 farmer subsample of the 600 families in the general survey. These forty were interviewed each day for a year as to their patterns of cash flow, employment and food consumption. After careful inspection of the results of the daily survey, four farms were selected for linear programming analysis. These farms were chosen to be as representative as possible of a wide range of conditions in the Nepalese middle hills. Since altitude is one of the important variants, the farms will hereafter be referred to by roman numerals according to their elevations, with I being the highest altitude farm and IV the lowest.

Table 2 presents characteristics comparing the four farms. The table shows the variability in farm size ranging from more than 1.3 hectares on farm III down to 0.2 hectare on farm II. Although there was little evidence of widespread caloric deficiency or malnourishment in the general survey, the four selected families exhibit nutritional problems when a careful seasonal breakdown is made. The percentage of total requirements that were met varied over the year, with the winter proving the most difficult for three of the four families. The high elevation farmer, I, appears to be the best off in terms of meeting caloric requirements, with intake being more than adequate in two of the three seasons. The two middle elevation farmers meet their caloric requirements in only one season, while the farmer at the lowest elevation is consistently below minimum calorie needs. Of the four, only the low elevation farmer drops well below minimum requirements for protein. His lack of calories in all seasons causes protein to be utilized for energy with ensuing protein deficiency. In part, the protein deficit experienced on farm IV is

Table 2. FOUR REPRESENTATIVE FARMS IN NUWAKOT DISTRICT, NEPAL

Characteristic	Unit	I	II	III	IV
Altitude of homestead	meters	1,974	1,280	910	546
Total cropland	hectares	0.44	0.20	1.3	0.28
Irrigated land	percent	34	36	74	55
Livestock					
Milch cows	number	1	--	3	1-2
She-buffalo	number	2-3	1	1	--
Ewes	number	4	4	3	--
Hens	number	2	4	--	2
Household size (in residence)	persons	5	4	8	3
Nutritional Requirements Met	percent				
Calories					
Early season Feb. 15-Aug. 14		121	86	100	87
Monsoon season Aug. 15-Dec. 14		119	82	98	89
Winter season Dec. 15-Feb. 14		96	103	97	73
Protein					
Early season		137	102	143	124
Monsoon season		137	97	146	127
Winter season		99	135	140	88
Riboflavin					
Early season		60	51	73	57
Monsoon season		86	54	75	60
Winter season		42	41	69	49
Niacin					
Early season		128	90	194	92
Monsoon season		123	88	103	85
Winter season		89	125	106	64

attributable to the difficulty of raising livestock in the heat and high humidity of low elevations.

In addition to calories and protein, the diets of the four farm families were evaluated in terms of adequacy of two minerals, calcium and iron, and five vitamins. The most serious deficiencies occurred in the availability of riboflavin and niacin as presented in Table 2. At no time during the year is sufficient riboflavin included in the diet of any of the families. Three of the four families had adequate levels of niacin during at least one season of the year, but only on farm III was dietary niacin sufficient year-round.

Nutritionally, farms II and IV appear to be in a poor position. In two seasons on farm II and year-round on farm IV diets are deficient in calories by from 11 to 27 percent. Moreover, in the season in which caloric intake is lowest, there is also insufficient protein. This results in true protein-calorie malnutrition, because there is no excess protein available to be utilized by the body to make up the calorie deficit. When this situation is coupled with inadequate riboflavin and niacin, the health difficulties related to malnourishment are compounded.

The purpose of the linear programming analysis carried out on the four chosen farms was to determine how income could be maximized under alternate sets of conditions. The general linear programming model was restructured to make it more suitable for analysis of Nuwakot district farms with nine modifications being made.

First, in all but one of the solutions, nutritional considerations were introduced as part of the constraints on the model. The maximand includes the value of produce retained for home consumption purposes and/or the purchase of food from the market place to meet nutritional requirements.

Second, the "optimal" solutions include the assumption that dietary patterns will also become "optimal" to meet nutritional requirements most efficiently.

Third, the amount of land was not allowed to vary. All available arable land is already being farmed and it is unrealistic to expect that a farmer could rent or purchase additional hectarage.

Fourth, the supply of labor from family members is computed to be eight hours a day multiplied by an appropriate factor to reflect age. On the basis of observation of the strength and industriousness of women, it was concluded that the coefficient of female labor should be identical to that of male labor. For the relative productivities of children, output levels for the farm in question were studied so that the amount of available labor in standardized units could be determined. The eight-hour day was chosen to reflect the average working unit over the whole year, on the basis of an estimate made from the daily survey data. Labor was allowed to be hired at the standard wage in the village in which the farm was located, but the members of the farm family were not allowed to work off the farm.

Fifth, requirements for nine dietary components were computed. These were calories, protein, calcium, iron, beta-carotene, thiamine, riboflavin, niacin and ascorbic acid, and were used in solutions involving various levels of dietary adequacy.

Sixth, historic levels of yields per hectare, as well as their farm gate prices in the season of harvest, were considered the starting point or benchmark for each farm. When observations were missing or, in the judgment of the investigators, distorted, coefficients for that crop were modified by statistics taken from neighboring farms.

Seventh, all operating costs, namely the hiring of labor and bullocks, and the purchase of food items for nutritional reasons, must have been met through capital borrowed during the year and paid back at the end of the year at an interest rate of ten percent.

Eighth, to replicate traditional attitudes toward the division between lowland and upland, and to reflect the near impossibility of formulating hypothetical input-output coefficients for lowland horticultural activities, the linear programming model was constructed so that upland crops could not be grown on lowland, and vice versa.

Ninth, there is an adherence to traditional production techniques which do not employ chemical fertilizers, pesticides, and fungicides.

In the original analysis, six solutions for each farm were approximated:

1) the simple short-run income maximization (allowing for enterprise adjustments which can be made within two cropping seasons) with no nutritional constraints;
2) the short-run income maximization with nutritional constraints and unlimited use of the market to meet consumption demands — the family may purchase food from the market and sell surplus production;
3) the short-run income maximization with nutritional constraints and no marketing option;
4) the short-run income maximization with nutritional constraints and marketing limited by a ceiling on borrowing of capital;
5) the short-run income maximization adjusted to reflect subsistance mentality. This means that 75 percent of farm hectarage is planted to cereal and legumes;

6) the long-run income maximization reflecting a cropping period ten years hence, including projected price relationships and allowing for changes in the levels of livestock and fruit tree production which were fixed during the short-run.

Presentation of the complete analysis of all six solutions for each of the farms would be repetitive and well beyond the scope of this paper. Results of solutions (2) and (6) will be examined for each farm to provide the reader with examples of the adjustments that could take place and their implications. For a complete discussion of all 24 linear programming solutions, see Calkins (1976, pp. 135,282).

Cropping Pattern Changes - In summarizing the linear programming results, three situations are presented in Table 3. The first page of the table presents the benchmark data, or the situation as it existed when the survey was taken. For example, net income on the four farms during the survey period ranged from $140 to $1,000. It should be noted that net income in the linear programming analysis refers to net income after family consumption. For each farm, season and type of land, the percentage of total hectarage devoted to the various types of crops is given.

The second page of the table is labeled "Short-Run Optimal Solution." This presents the short-run results, previously explained as solution (2). The following are the specifications of the solution:

1. permanent crop acreages and livestock levels are fixed;
2. buying and selling activities are allowed;
3. there are no changes in technology;
4. there is no limit to capital borrowing; interest charges of 10 percent are assumed for all borrowing activities;

Table 3. THE SEASONAL USE OF LAND FOR PRODUCTION ACTIVITIES ON FOUR REPRESENTATIVE FARMS NUWAKOT DISTRICT, NEPAL

	Benchmark Situation				
	Proportion of Land Devoted To				
Zone/Solution	Grain	Legumes	Vegetables	Fruit	Fallow
	-Percent-				
I					
Early lowland	8.3	0	0	0	91.7
Monsoon lowland	100.0	0	0	0	0
Early upland	68.9	1.6	16.9	12.6	0
Monsoon upland	17.6	0.7	69.1	12.6	0
Winter upland	0	0	14.0	12.6	73.4
			Net Income: $360		
II					
Early lowland	46.9	0	37.4	0	15.7
Monsoon lowland	84.3	0	0	0	15.7
Early upland	74.3	7.5	11.0	7.2	0
Monsoon upland	65.5	14.9	12.4	7.2	0
Winter upland	0	0	8.0	7.2	84.8
			Net Income: $340		
III					
Early lowland	10.5	0	0	0	89.5
Monsoon lowland	96.5	3.5	0	0	0
Early upland	48.3	32.2	16.8	2.7	0
Monsoon upland	40.3	31.3	25.7	2.7	0
Winter upland	0	0	1.6	2.7	95.7
			Net Income: $1,100		
IV					
Early lowland	87.6	0	2.0	0	10.3
Monsoon lowland	95.4	0	2.5	0	2.1
Winter lowland	25.0	0	2.1	0	72.9
Early upland	46.3	13.0	20.3	20.4	0
Monsoon upland	43.5	13.0	23.1	20.4	0
Winter upland	0	0	9.7	20.4	69.9
			Net Income: $140		

Table 3 (continued)

Zone/Solution	Short-run Optimal Proportion of Land Devoted To: Grain	Legumes	Vegetables	Fruit	Fallow
	- - - - - - - - - - - - -percent- - - - - - - - - - - - -				
I					
Early lowland	100.0	0	0	0	0
Monsoon lowland	100.0	0	0	0	0
Early upland	0	0	88.7	11.3	0
Monsoon upland	0	0	88.7	11.3	0
Winter upland	0	0	88.7	11.3	0
			Net income: $1,260		
II					
Early lowland	30.2	0	69.8	0	0
Monsoon lowland	100.0	0	0	0	0
Early upland	0	89.6	3.2	7.2	0
Monsoon upland	0	0	92.8	7.2	0
Winter upland	0	0	3.2	7.2	89.6
			Net income: $710		
III					
Early lowland	100.0	0	0	0	0
Monsoon lowland	100.0	0	0	0	0
Early upland	0	91.3	5.9	2.7	0
Monsoon upland	0	0	97.3	2.7	0
Winter upland	0	0	0	2.7	97.3
			Net income: $1,130		
IV					
Early lowland	100.0	0	0	0	0
Monsoon lowland	100.0	0	0	0	0
Winter lowland	0	0	100.0	0	0
Early upland	0	0	84.8	15.2	0
Monsoon upland	0	0	0	15.2	84.8
Winter upland	0	0	84.8	15.2	0
			Net income: $240		

Table 3 (continued)

Zone/Solution	Long-run Optimal Proportion of Land Devoted To				
	Grain	Legumes	Vegetables	Fruit	Fallow
	-percent-				
I					
Early lowland	100.0	0	0	0	0
Monsoon lowland	100.0	0	0	0	0
Early upland	0	0	100.0	0	0
Monsoon upland	0	0	100.0	0	0
Winter upland	0	0	100.0	0	0
	Net income: $1,070				
II					
Early lowland	100.0	0	0	0	0
Monsoon lowland	100.0	0	0	0	0
Early upland	0	100.0	0	0	0
Monsoon upland	0	0	100.0	0	0
Winter upland	0	0	0	0	100.0
	Net income: $1,020				
III					
Early lowland	100.0	0	0	0	0
Monsoon lowland	100.0	0	0	0	0
Early upland	64.7	35.3	0	0	0
Monsoon upland	64.7	0	35.3	0	0
Winter upland	0	0	35.3	0	64.7
	Net income: $1,910				
IV					
Early lowland	100.0	0	0	0	0
Monsoon lowland	100.0	0	0	0	0
Winter lowland	63.7	0	36.1	0	0
Early upland	0	0	100.0	0	0
Monsoon upland	0	0	0	0	100.0
Winter upland	0	0	100.0	0	0
	Net income: $160				

SOURCE: Survey data, Nuwakot, Nepal, December, 1973 - December, 1974.

5. There is no source of off-farm employment or income;
6. the farmer is out to maximize the net sale value of his farm produce after meeting all family nutritional requirements.

The optimal long-run solution, presented in the third page of the table, has the following specifications and constraints:

1. price expectations will undergo cumulative chagges according to trends recorded over the last ten years;
2. fruit trees will be allowed to vary from their present area;
3. numbers of buffalo, goats, and chickens will also be allowed to vary freely;
4. dairy-cow herd size will be allowed to vary within the range of one to four units;
5. the farmer is assumed not to take advantage of improved technological options;
6. wage rates will remain constant.

Both the long- and short-run optimal solutions are at the 100 percent level of nutrition. Lowland refers to irrigated fields suitable for paddy production, while upland refers to unirrigated fields. The seasons are defined as follows:

Farm / Season	I	II
Early lowland	Nov. 15-June 14	Nov. 15-July 14
Monsoon lowland	June 15-Nov. 14	July 15-Nov. 14
Winter lowland	--	--
Early upland	Feb. 15-Aug. 14	Feb. 15-Aug. 14
Monsoon upland	Aug. 15-Dec. 14	Aug. 15-Nov. 30
Winter upland	Dec. 15-Feb. 14	Dec. 1-Feb. 14
	III	IV
Early lowland	Dec. 1-Apr. 14	April-Aug.
Monsoon lowland	Apr. 15-Nov. 30	Sept.-Nov.
Winter lowland	--	Dec.-March
Early upland	Apr. 15-July 31	Apr. 15-July 31
Monsoon upland	Aug. 1-Dec. 14	Aug. 1-Dec. 14
Winter upland	Dec. 15-Apr. 14	Dec. 15-Apr. 14

Source: Survey Data, Nuwakot District, Dec. 1973 - Dec. 1974.

There is an overwhelming mandate in both the short- and long-run solutions to continue to devote lowland acreages to the production of grains. This is mainly because it is a considerable distance from the homestead to low lying fields. Vegetables require more continuous and larger amounts of labor than grain. It would involve an inordinate amount of walking time over steep terrain if vegetable production were followed on a significant proportion of lowland. Only in the case of white potato (a vegetable), which should occupy 69.8 percent of early lowland in the short-run optimal solution of farm II, as well as 100 percent of winter lowland on farm IV, is the monopoly of lowland grain production broken. Potatoes should also occupy 36.1 percent of winter lowland in the long-run solution of farm IV. Since even potato is principally a source of calories in the diet, this implies that most vitamins and minerals will be derived from upland production of other vegetables and fruits.

Despite its historic hegemony, grain production in upland fields is eliminated in the short and long-run solutions, except in the case of the long-run on farm III. This suggests that the combination of higher grain needs for livestock and the adverse turn in prices of other commodities has restored to grain some of its comparative profitability on this farm.

Readers may be puzzled as to why land is left fallow in an area of extremely small farms and food scarcity. Fallow land results primarily from the growing of a profit maximizing crop which extends over two or more seasonal periods. For example, on farm III, the short-run optimal solution indicates 97.3 percent of monsoon upland is planted to vegetables. These are harvested during the early part of the winter upland season, and the land then remains fallow.

Vegetables occupy 100 percent of all long-run cropped upland in farms I and IV and share about evenly with legumes on farm II. The long-run position of vegetables is interesting. Their production increases despite the fact that extrapolated price relationships used in the solution imply a worsening in the price of vegetables relative to competing crops. Since legumes are considered horticultural in our study, vegetables predominate entirely in upland fields. There is a clear mandate for an intensification into fewer varieties of and greater land area devoted to vegetable products on upland fields in both the short and long-run optimal solutions.

Despite the wide number of varieties included as options in the linear program, a relatively small number of horticultural crop varieties are earmarked for specialization in the optimal solutions. These are potato, green-beans, rape, radish, okra, silam, ginger and chili. Of these eight varieties, potato and rape appear in three of four farms and green-beans appear in two. This suggests that these crops generate higher incomes per unit of land over a wide range of soil, micro-climate and factor ratios and that intensified research into a limited number of historic vegetable varieties is a feasible avenue to horticultural development.

Fruit production on the upland is eliminated in the optimal long-run solution in all four farms. This demonstrates the low levels of productivity resulting from the traditional cultural practices in fruit production at the present time. By the very nature of the definition of the short-run, these activities continue to appear through the short-run optimal solution.

Net Farm Income - The linear programming analysis demonstrated that, in the short-run, all four farms could adjust enterprise combinations in such a way as to increase net farm income while still meeting 100 percent of the families' nutritional requirements. The short-run solution presented in Table 3 indicates that the largest absolute increase in income occurred on farm I, where income rose from $360 to $1,260. To some degree the ability of this farmer to make profitable adjustments is not characteristic of areas within the middle hills. Farmer I is located on a hard-surfaced road and the bulk of his increased income is attributable to his ability to add horticultural production on his upland fields. This is primarily increased vegetable production which can be sold in the Kathmandu market. The solution demonstrates the importance of market access, for farmer III is able to increase his net farm income by only $30 even though he has a considerably larger land base and assets.

Farmer III was apparently operating his farm at close to optimal conditions given the constraints of market access and availability of inputs. In contrast, farmers II and IV, while starting from a relatively low income base, could more than double short-run net income if they altered cropping patterns.

Surprisingly, the long-run farm income earned by farmers I and IV declined relative to the short-run optimum. This may be explained by the fact that a price trend was used. Prices were plotted for the ten years prior to the study and the trend extrapolated to determine the most feasible future prices. In general, cereal prices remained approximately stable; however, the prices of other crops have shown a downward trend. In the case of farmers I and IV, meeting nutritional requirements involved the production of crops whose prices exhibited a downward trend. For this reason it is feasible that the long term net farm income generated by an optimum cropping pattern may actually decline. Farms II and III showed an increase in long range net farm income since they were able to meet nutritional requirements and other model constraints through crops that did not have a downward price trend. In all cases, farms could be reorganized so that long term net farm income would be greater than the conditions which actually prevailed. This is particularly important when we consider that the long term solution also enhances nutrition for all four families.

In the short and long-run, the optimal solutions indicate major decreases in upland grain production, with concomitant increases in upland vegetable and legume production. What do these changes imply for labor patterns?

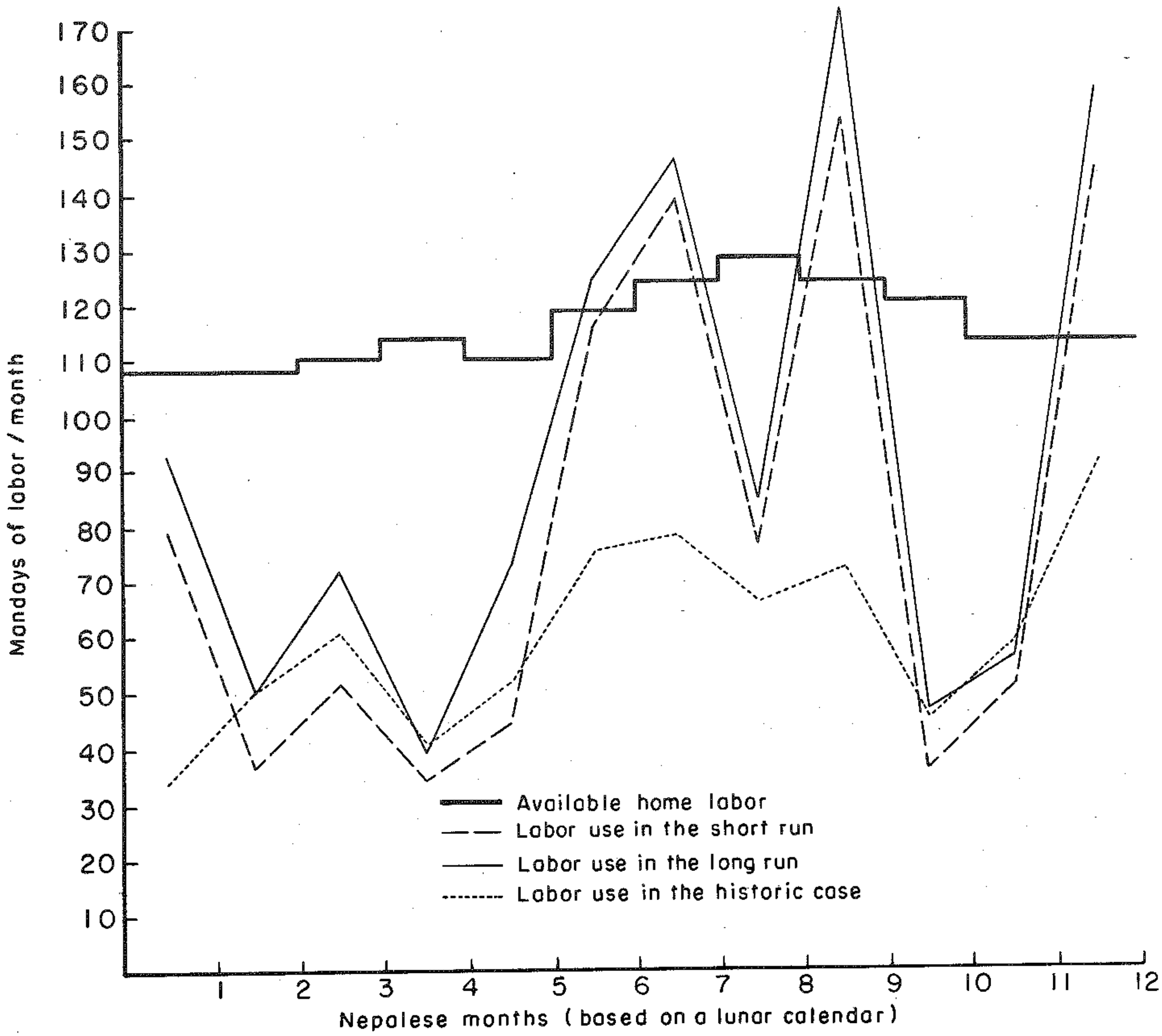
Farm Labor Requirements - A shift of more and more upland into legume-vegetable rotations is commonly cited as a benefit of horticultural intensification in that it presumably increases the demand for family labor and reduces the seasonal variability in demand for family work. To test the validity of these assumptions, labor requirements by month were plotted for each of the four farms. Separate lines were used to depict labor requirements as the farm is presently operated and what changes would take place under the short and long-run optimal solutions.

Figure 2, which is representative of the types of graphs made for all four farms, shows a plot of monthly labor requirements for farm I. The heavy line depicts the amount of labor which could be supplied by household members. The reader can judge the amount of labor which must be hired in, or conversely, the underemployment of family members for any month by gauging the area above and below the heavy line. It may be seen that on this farm, where the original level of labor allocated to vegetable cultivation was the highest, the assumed results do not hold. While the increasing devotion of land to non-leguminous vegetables entails a considerable rise in total labor requirement, it also amplifies the wariability of family labor use.

It is only on farm II that the assumed results are indicated. The shift of more and more upland into legume-vegetable rotations consistently decreases the variability in labor utilization. Horticultural specialization on this farm thus leads to higher and more consistent demands on labor.

As for farm III, where non-grain crops have historically had the lowest levels of profitability in terms of marginal returns to both land and labor, there is increased devotion of land to vegetables and legumes

FIGURE 2. FARM I: LABOR USE IN LONG- AND SHORT-RUN OPTIMAL SOLUTIONS AT THE 100% LEVEL OF NUTRITION COMPARED WITH THE HISTORIC CASE



in the short-run, but decreased land allocation to these crops in the long-run. The highest levels and variability of labor use occur in the short-run and decline somewhat in the long-run, but do not fall to benchmark levels. Grain area in the lowland does not change from the short-run to the long-run solution, and livestock numbers are consistent. These two forces dampen changes in labor demand from the short-run to the long-run solution. It may be concluded that on farm III the level of vegetable-legume rotation is positively correlated with both the magnitude and variability of labor use. The situation on this farm is thus similar to that on farm I.

Finally, on farm IV in the short-run optimal solution, the increase in overall area devoted to vegetable crops engenders a higher but less consistent level of labor use. In the long-run, where the maximum amount of land is devoted to vegetable production, the level of labor use continues to increase but the variability decreases. This is due not to the influence of vegetable crops, but to the effects of increased livestock and reduced fruit production. Thus, on farm IV as on both farms I and III, vegetable and legume specialization entails higher but less consistent use of labor. While this result promises to provide more overall employment in the agricultural sector as it generates more income, the problem of seasonal underemployment is intensified.

Household Nutritional Status - As to how nutritional movements parallel the above trends in income and employment, nutrient short-falls are automatically eliminated by the stipulation that 100 percent of nutritional requirements be met by the optimal solution. Thus, as levels of income and overall employment increase, so do the levels of nutrition. The applicability of these results depends upon both the effectiveness of nutritional education and the ability to buy and sell large amounts of produce on the market to effect a kind of nutrient arbitrage.

The reader should keep in mind that enterprise combinations to meet both income and labor utilization objectives, may be significantly influenced by the 10 percent interest charged on capital borrowed for production activities. The following list indicates products purchased and/or withheld from the market.

	Farm			
	I	II	III	IV
Bought, without	soybean	maize	ricebean	millet
buying constraint:	radish	millet		ricebean
	yam	ricebean		snakegourd
	pumpkin	rape		
	mustard			
	greens	guava		
	peaches			
Retained, without	peaches	maize	rape	rape
buying constraint	milk	guava		

Several observations may be made about the above commodities:

In every case the cheapest legume crop is purchased to help meet caloric, protein and vitamin demands. In all but farm I, where soybeans are bought, ricebean has the lowest price per unit of nutrients supplied.

Grain is purchased by farms II and IV. These are the farms with the lowest amount of arable land and the highest incidence of historic protein-calorie malnutrition. Millet is the cheapest grain crop available for purchase and is a good source of nutrients, but in the case of farm II, it is found economical to purchase maize as a source of beta-carotene.

Partly as a result of seasonal inability to produce them, green leafy vegetables and fruits are purchased only at the two highest elevations (farms I and II), showing that vitamins A, C and the B- complex tend to be more critical at these altitudes.

Gourd crops (pumpkins and snakegourd) and yams are purchased by both high and low elevation farms I and IV. They are an inexpensive source of nutrients and purchases are necessitated because low yields make adequate home production of these crops infeasible.

On farms I and II, fruit is retained for home consumption, while on farms III and IV, rape greens are retained. This implies that their selling price is not high enough to make the purchase of the vitamins they contain profitable, especially with the 10 percent cost involved in borrowing capital for consumption purchases. It also echoes the conclusion from the regression analysis that fruits are nutritionally more important at high altitudes and vegetables at low altitudes, despite the fact that their comparative productive advantages are reversed. Rape is so important on farm IV that area devoted to its production is increased as nutritional demands rise, even when commodity purchases are allowed. Milk is retained for its calcium on farm I and maize for its calories and beta-carotene on farm II. Apart from these five commodities, it is profitable to engage in nutrient arbitrage when capital borrowings are unrestricted.

The predominance of legumes, vegetables, and fruit in these purchased and retained commodities has been noted. It bears re-emphasis, however, that, whether all nutrient demands are met by on-farm production or supplemented with purchases from the market, the contribution of legume, green leafy vegetable, tuber, gourd, and fruit products to the diet is considerable.

Additional Findings - As indicated earlier, this paper does not present detailed results of the linear programming analysis for all of the six solutions run in the original study. A brief summary of some of the more important findings of the additional solutions will be presented here. For further details refer to Calkins (1976, p. 135-282).

Actual average household income of the four farms was $485 during the year the study was undertaken. Linear programming analysis suggests that an optimum enterprise combination whose only objective is income maximization with no considerations of nutrition, could raise average income as high as $1,058,about $225 higher than when all nutritional requirements must be met. With this objective, the enterprise combinations would be far less complex than actually occurred. Land would not, however, become completely specialized in the most profitable crop. This is due to the fact that family labor constraints would necessitate hiring labor. At some point the cost of hired labor would begin to detract from net income.

It is not realistic to assume that farmers will forsake their strong feelings about self-sufficiency and move entirely into a market economy. To replicate traditional attitudes, a linear programming model was run for each farm with the constraint that at least 75 percent of the crop land be planted to cereals and leguminous crops. In addition, the model required that the farmer meet 100 percent of his nutritional demands, but allowed him unlimited capital borrowing and buying options. Under this model, average farm income would fall to $355, a decrease of $130 from the actual income situation and a decline of almost $700 from the optimum enterprise combination indicated in the short-run solution presented in Table 3. It is interesting to note that on three of the four farms this "subsistence" constraint actually reduced net income. In the actual case, the farmers were involved in the production of a variety of crops other than cereals and legumes. Sale of a part of these crops provided a higher level of income than could be achieved within the constraint. Their nutritional levels were, however, far from adequate, and we see here a striking trade-off between income and nutrition. In essence, these farmers would sacrifice on the average $130 of cash income to obtain a nutritionally adequate diet for their family. The results also indicated that even though farmers were strongly oriented towards self-sufficiency, they were devoting more than 25 percent of their land to crops other than cereals and legumes.

PROSPECTS FOR INTRA-REGIONAL TRADE

A basic tenet of the development strategy of Nepal is that increased specialization and trade between hill areas and the plains will improve employment and income in both areas. It is argued here that while hill/plains interaction is important, there can be significant gains associated with trade within Nepal's middle hill area. There are many apparent advantages to specializing in the production and trade of commodities at the district rather than the national or regional level. Nine will be briefly discussed.

First, transportation costs per unit of produce shipped and, more importantly, the cost of road and other infrastructural investments are vastly reduced. Moreover, employment of rural labor is increased while dependence on imported fuel and machines is minimized.

Second, markets are visible and known in the within-district case. This means that it is easier for farmers to make informed marketing decisions on the basis of price information than in the interregional case. The farmers are much more willing to trade in markets in which they have knowledge and confidence.

Third, produce -- especially fruit and vegetable products -- arrives at the consumer household in much better aesthetic and nutritive condition. Since the government of Nepal's emphasis for agricultural development in the middle hills is on fruit and vegetables, this is no small consideration.

Fourth, government administrators and/or middlemen are not necessary to facilitate within-district trade. This means that the establishment and maintenance of a trading pattern are much less costly in terms of scarce trained personnel and financial costs of administration.

Fifth, related to the above consideration is the ability to combine research, extension and trade administration in a unified system of micro-climatic specialization. If an extension worker were assigned to work with farmers in a single, clearly-defined micro-climatic zone and to be responsible mainly for knowledge in the production and trade of the few commodities earmarked for development, the efficiency and competence of his work would stand to increase dramatically. At the same time, research, instead of being restricted to government farms, could be made more relevant to specific conditions of micro-climate and other location specific constraints at the sub-regional level. Top-level research and extension personnel, instead of being confined to the district centers, would follow increasingly the growing tendency in agricultural administration in the hills--to decentralize the sources of information in order to increase the pertinence of recommendations given out and the use of feedback information from trials under farmers' conditions.

Sixth, such specialization could entail investment in irrigation and dairy components as lures to other types of development. Without the prospect of trade for the grain and dairy commodities which are the favorite foods of hill farmers, it is unlikely that farmers in other micro-climatic pockets will devote large acreages to horticultural crops.

Seventh, as a further extension of this process, a market for the surpluses produced in the optimal solutions for a given area would be relatively more assured. In other words, by making the best use of the differing micro-climates within a district, rather than viewing it as a monolith, a concentration in the promotion of varieties under inefficient conditions for export outside the district could be avoided in favor of finely-tuned production practices geared to within-district markets.

Eighth, even if in the long-run, inter-regional trade of the hills/ plains type is the optimal pattern, the development of a specialization-cum-trade mentality in the within-district case serves as a logical stepping stone in the short-run. It seems too much to expect farmers to behave as confident and efficient long-distance traders.

Ninth, in this connection, the cooperative movement, seldom successful at any distance from urban centers, could develop as farmers realize the gains from extending contiguous cropping practices from grain to non-grain crops, as well as the enhanced efficiency of group negotiation and transport.

These key advantages may be obtained in a within-district trade model. Thus, if any comprehensive set of incentives to specialization and trade is to be developed, it will be through such a pattern. It operates on the district level, is applicable to all hill districts and makes productive use of a reallocation of existing resources under existing technology. It also allows for the testing needed to improve technology, includes guaranteed price and drastically reduces marketing costs.

The analyses in this study show that all irrigated fields, regardless of elevation, should be devoted to cereal crop production. Any additional cereal production required should be grown on unirrigated land below 1,200 meters.

Results additionally indicate that unirrigated fields above 1,200 meters should specialize in the production of vegetables. These patterns hold for both the 600 farms of the general survey and the four farms subjected to linear programming analysis. Thus, within each land base there could be an exchange of low altitude grain for high altitude vegetables. To satisfy fruit demands, farmers may either continue to grow fruit as at present, which is perhaps the simplest expedient, or have the lower regions in land bases two and three engage in fruit production. This would bring forth an efficient but more complex trade model.

Several analytic procedures were incorporated to determine the comparative advantage of various enterprises on high and low elevation farms. These results provide policy makers with useful guidelines. In development priorities, low elevation grain crops and irrigation should be given prime attention, with fruit also produced if local demand is good or perhaps for trade outside the district. At high elevations, emphasis should be given to vegetables, with the production of popular dairy items also encouraged. As market awareness develops, this type of pattern would allow for pockets of micro-climatic specialization, either down the side of a single mountain face or perhaps among land bases.

Prices would equlize and the standard of living would improve for dwellers of all areas.

It seems, therefore, that within-district or intra-hill trade will offer at least as viable exchange possibilities as will the hills/plains integration strategy forwarded by the government.

SUMMARY AND CONCLUSIONS

The government of Nepal has made increased agricultural production the centerpiece of its development strategy. The policy has been to promote grain production in the terrai or plains, while the middle hills region is to become more specialized in fruit and vegetable production. The theoretical basis of this policy is that the two altitudinal zones would gain from specialized agricultural production and trade.

Extreme population pressure and a deteriorating natural resource base make imperative the improvement of farm productivity in the middle hills region. It is felt that increased horticultural production will be the engine of growth for a betterment of the level of living within this region. Despite this, no detailed micro-level survey as to the actual and potential contribution of fruit and vegetable production to the well-being of middle hill families has previously been undertaken.

This study examines a representative area of the middle hills to determine what agricultural patterns currently exist, the ability and willingness of farmers to specialize in horticultural production, and the possible effects on their income, employment and nutrition should they do so.

Two types of survey were employed to gain benchmark information. The first consisted of interviews with six hundred farmers of Nuwakot

District to obtain data on farm size, production assets and the most important cropping patterns. The second survey involved a year of daily interviews with a forty farm sub-sample. This provided detailed information as to cash flows, labor allocation, trade, food consumption and nutritional status of households.

Summary statistics from the surveys indicate that distance from the Kathmandu market and altitude are the most important variables bearing on land utilization and family welfare. Farm size and the value of purchased inputs such as fertilizer decrease significantly with distance from market. It was found that area devoted to cereal grain production, a measure of subsistence, increases with distance from a trading center. Farms at lower elevation tend to have a higher cropping index and exhibit greater seasonal variation in labor requirements. On all farms surveyed, horticultural production used a small fraction of the land, labor and capital in agriculture. Rice and pulse dominated at lower elevations. A transitional zone was identified at approximately 1,200 meters. Above this level, production of maize and millet dominate agricultural activities. This elevation demarcation also separates high caste Hindu households from the higher elevation Tamang families who are Budhists and speak a Tibeto-Burman language.

Linear programming analysis was used to determine what adjustments in enterprise combinations were feasible if increased horticultural production were promoted. The linear programming solutions indicated that all irrigated fields, regardless of altitude, should be devoted to grain production. The analysis pinpointed the fact that if the constraints of marketing problems and subsistence mentality are relaxed, unirrigated upland fields should be devoted to vegetable production, despite the fact that grain crops have traditionally occupied this land. The nutrition, employment and income of families could be improved if specialization along these altitudinal lines took place and greater exchange occurred. Ideal production patterns suggest that a limited range of vegetable varieties be produced. Only eight varieties were identified as contributing to meaningful specialization.

As the result of seasonal planting and harvesting peaks associated with reliance on this small number of vegetables, there would be increased variability in labor use over the year.

It is concluded that the prospects for increased specialization and trade between the hills and plains is not likely to be as efficient or feasible as "within hill" specialization and trade. To establish interdependence between the hills and terrai would involve heavy capital expenditures on a highway network, and erosion of traditional distrust between the two regions. It would also necessitate the creation of pricing policies and border regulations which would make it more desirable for Nepalese grain farmers in the plains to ship their surplus to the hills rather than to India.

To make "within hill" trade most beneficial, micro-climatic pockets appropriate for specialization in different crops must be identified and developed. A concentration of government research and extension efforts in these areas could involve a viable and trust inspiring marketing mechanism for farmers leery of specialization and reliance on the market place. It would also be an alternative to capital intensive outlays on a large road complex linking outlying areas of the hills to terrai markets. Such an approach to integrated rural development is thought to be the best mechanism for overcoming traditional patterns of thought and behavior which now act as deterrents to any but marginal shifts in the allocation of resources on the small farms of the middle hills.

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