AN OPTIMUM PLANNING FOR INTEGRATING CITRUS IN NEPALESE HILL FARMING SYSTEMS

DEVENDRA GAUCHAN

A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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ABSTRACT

The hill region of Nepal, which supports nearly half of the country's population and where environmental degradation is severe, the declining production and return from existing crop based systems is barely sufficient to sustain the needs of increasing population. In this context, integration of high value fruit tree such as citrus (orange) could be an alternative to improving the income status of small farmers without impairing the productivity of the existing resource base.

The main objectives of this study were to examine the existing farming systems and analyze the economic viability of integrating citrus farm plans under various economic and policy environments and resource endowments of the farm households. The study also aimed to assess the major constraints to integrating citrus into present hill farm systems.

This study uses cross sectional data of 1993 from 123 sampled households of two study sites of Kavre district, in mid hill region :Patlekhet and Sankhu which represent non citrus and citrus based systems respectively.

The sampled households of both study sites were classified into four groups based on land size. The labor and capital resource availability of farm households were found related to farm size. In Sankhu site orange was found more profitable and farm households preferred to grow it than competing enterprize maize because of economic and soil conservation benefits.

A farm level multiperiod linear programming model for a planning horizon of twenty years was employed in order to maximize present value of gross margin subject to various resource constraints and consumption demand. Econometric method was used to estimate the consumption demand and later incorporated in the programming model.

The results of the multiperiod programming model revealed that the incremental benefits from the integration of orange fruit in two different production systems and resource endowments of the farm households were found higher over existing systems. For the optimum plan, the gross margin of all sized farms of both the production systems increased 10 -17% over the existing ones. The smallest farm still have some land devoted for rice production, while medium sized farms devote all the land for orange.

The sensitivity analysis of existing citrus based systems showed that off-farm employment is the most significant factor which provides all the farm sizes to incorporate orange. But the price of orange, discount and wage rates have less impact on orange integration.

Despite the economic viability of orange integration, appropriate policy intervention such as emphasis on citrus based farming systems and improvement in institutional support services particularly extension and marketing support are needed to raise the long term income needs of the small farmers in addition to protect the deteriorating economy and ecology of the mid hills of Nepal.

ชื่อวิทยานิพนธ์ การวางแผนปลูกส้มเพื่อผสมผสานในระบบฟาร์มบนที่สูงของเนปาล

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บทคัดย่อ

ในบริเวณพื้นที่สูงตอนกลางของประเทศเนปาลซึ่งมีประชากรอาศัยอยู่ประมาณครึ่งหนึ่งของประชากรทั้งหมดของประเทศ การผลิตและผลตอบแทนของเกษตรกรที่ขึ้นอยู่กับระบบพืชแบบดั้งเดิมนั้นแทบจะไม่เพียงพอที่จะสนองต่อความต้องการของเกษตรกรได้อย่างถาวร การเผชิญกับปัญหาความกดดันของจำนวนประชากรที่เพิ่มสูงขึ้น ความเสื่อมโทรมของทรัพยากรธรรมชาติ และการลดลงของประสิทธิภาพการผลิตของระบบเกษตรแบบดั้งเดิมนั้น ทำให้การปลูกพืชที่มีการผสมผสานไม้ผลซึ่งมีมูลค่าสูงดังเช่นส้มรวมเข้าอยู่ในระบบจะเป็นทางเลือกหนึ่งสำหรับการเพิ่มรายได้ให้แก่เกษตรกรรายย่อยในระยะยาว โดยปราศจากการสูญเสียประสิทธิภาพของแหล่งทรัพยากรที่มีอยู่เดิม

การศึกษานี้มีวัตถุประสงค์หลักคือ เพื่อศึกษาระบบฟาร์มปัจจุบันของเกษตรกร และวิเคราะห์ความอยู่รอดเชิงเศรษฐกิจของระบบฟาร์มที่ผสมผสานส้มเข้ากับระบบปัจจุบันภายใต้ข้อจำกัดในด้านทรัพยากรและสภาพแวดล้อมเศรษฐกิจต่าง ๆ การศึกษานี้ใช้ข้อมูลจากการสำรวจเกษตรกรจำนวน 123 ครัวเรือนจาก 2 หมู่บ้านในอำเภอ Kavre ในเขตที่สูงของเนปาล ปี 1993 โดยมีหมู่บ้าน Patlekhet และ San'khu เป็นตัวแทนของระบบฟาร์มที่ไม่มีส้มและมีส้มตามลำดับ

เกษตรกรทั้งหมดแบ่งได้เป็น 4 กลุ่ม ตามขนาดของที่ดิน จากการวิเคราะห์พบว่า จำนวนแรงงานและทุนมีความสัมพันธ์กับขนาดของฟาร์ม สำหรับระบบฟาร์มที่มีส้มนั้นพบว่า ผลตอบแทนของส้มดีกว่าข้าวโพดซึ่งเป็นพืชแข่งขัน และเกษตรกรพอใจปลูกส้มด้วยเหตุผลทางเศรษฐกิจและสังคม และการอนุรักษ์ดิน

การวางแผนฟาร์มด้วยแบบจำลอง Multiperiod Programming ถูกนำมาใช้เพื่อเป้าหมายการสร้างมูลค่าปัจจุบันของผลตอบแทนสูงสุดสำหรับระยะเวลา 20 ปี ภายใต้ข้อจำกัดด้านทรัพยากรและความต้องการบริโภคซึ่งประมาณการด้วยวิธีเศรษฐมิติก่อนนำไปไว้ในแบบจำลองข้างต้น

ผลการวิเคราะห์แผนฟาร์มที่เหมาะสมพบว่า เกษตรกรขนาดเล็กที่สุดและใหญ่ที่สุดควรเก็บที่ดินบางส่วนไว้สำหรับปลูกข้าว และที่เหลือปลูกส้มทั้งหมด แต่เกษตรกรขนาดกลางควรปลูกส้มทั้งหมด รายได้สุทธิจากแผนฟาร์มนี้สูงกว่าระบบฟาร์มดั้งเดิมทั้งสองของทุกขนาด (ประมาณ 10-17 %) และจากการวิเคราะห์ความอ่อนไหวพบว่าปัจจัยที่สำคัญที่สุดคือการจ้างงานนอกไร่นาซึ่งเปิดโอกาสให้เกษตรกรทุกขนาดของระบบส้มที่มีอยู่แล้วปลูกส้มได้มากขึ้น ส่วนราคาของส้มอัตราคิดลด และอัตราค่าแรงงานมีผลน้อยกว่าการจ้างงานนอกไร่นา

แม้ว่าการผสมผสานส้มเข้าไว้ในระบบฟาร์มจะมีความเป็นไปได้เชิงเศรษฐกิจก็ตาม แต่ก็ยังจำเป็นที่จะต้องมีนโยบายที่จะสนับสนุนให้มีการผสมผสานส้มในระบบฟาร์มให้ชัดเจน และมีการสนับสนุนในด้านการส่งเสริมการตลาด เพื่อยกระดับรายได้ของเกษตรกรขนาดย่อม และป้องกันสภาพทางเศรษฐกิจและสภาพแวดล้อมที่กำลังเสื่อมโทรมของแถบพื้นที่สูงตอนกลางของประเทศเนปาลด้วย

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CHAPTER I

1. INTRODUCTION

1.1 Statement of the Problems

The livelihood of the hill farmers in Nepal is traditionally sustained by two major components of the mixed farming systems: crops and livestock. However, since recently their livelihood in the hill terrain is threatened by the vulnerability of these two sectors as a result of increasing population pressure and deterioration of natural resource base.

The lack of remunerative alternative income and employment opportunities in the hills have forced farmers to over exploit existing land and expand cultivation to steep slopes and marginal areas. Deteriorating soil fertility and increasing erosion from cultivated land have resulted low and declining return from traditional annual (cereal) crop based production systems.

Furthermore, the livestock raising which has been traditionally a major source of cash income for the hill farmers has become no more remunerative during recent years as a result of deforestation and subsequent feed scarcity (APROSC, 1989). Increased emphasis on livestock development in the hills without proper management would further increase deforestation and soil erosion from grazing land (Kaini, 1993a). The nature of hill topography, marginality and fragile resource base also impede the possibilities of further improvement in hill economy through wide sclae agricultural intensification which is commonly found in low land (Terai).

Despite the above problems, the region is still least prioritized in terms of both developmental and conservation initiatives. Past agricultural developmental policies of government were also too broad and was mostly emphasized for cereal (grain) production. There was a lack of recognition of mountain characteristics during the formulation of periodic plans and programs (Shrestha and Yadav, 1992). This has adversely affected the environmental conditions in the hills as fragile slopy areas are brought under cultivation (Yadav, 1991).

Therefore, the economic conditions of hill farmers have worsened over time and the region is facing alarming situation of food scarcity, malnutrition and out migration. The absence of appropriate institutional mechanism thus, seems to be the weakest factor in the failure to bring about the basic transformation of hill agriculture in Nepal (ICIMOD, 1989).

1.2 Rationale

1.2.1 Fruit tree Integration as an Alternative Strategy

In the deteriorating economic and environmental situation of Nepalese hill region, the best strategy for farm improvement would be the integration of high value perennial crops such as fruit trees that can improve the viability and capability of existing farming systems. This is because the middle hill region of Nepal provides a `niche' for growing specific high value activities like fruits (Jodha, 1990).

Considering the geoclimatic conditions, it is obvious (Table 1) that increased emphasis on fruit tree production in the hills offers substantial improvement in farm income (Calkins and Sisler, 1978; Calkins, 1982; Anonymous, 1987; Kaini, 1993a). Fruit based farming system can play unique role for improving income status of small farmers because the productivity and return from fruit trees are higher and more stable than the traditional field crops in the hills (APROSC, 1989; Kaini, 1993a).

Integration of fruit trees with slight but meaningful modification of farming systems can be adopted by the farmers wherever transportation and market facilities are developing. Considering the small size of holding, resource poor and capital starved situation of hill farmers this could be a better strategy than present government's policy of promoting cereal crops and monoculture of fruit trees. Integrating market oriented fruit production without completely sacrificing subsistence autonomy will protect small farm households from extreme vulnerability to the vagaries of market economy and natural environment.

Table 1: Comparative costs and returns of selected fruit trees and Cereal crops production in the hills of Nepal.

Crop	Average Cost of Production (Rs/Ha)	Average Yield (kg/ha)	Gross income (Rs/ha)	Net Benefit (Rs/ha)
Maize	5,164	1,500	7,875	2,711
Wheat	5,252	1,200	7,128	1,876
Citrus*	5,302	10,000	8,849	3,547
Apple	2,979	10,000	7,433	4,454

Citrus* : It includes mainly mandarin and sweet orange (Junar).

Note: Cost of Production and benefits are present value of cost and benefit stream discounted at the rate of 15% per annum divided by the number of years of economic life. Hence, the net benefits are largely understated for fruit trees.

Source: East Consultant, 1990

1.2.2 Prospects for Citrus fruit Integration

The agroclimatic conditions of mid- hill region provides diverse environment for growing various type of fruit trees. Among fruit trees, citrus species, especially oranges (mandarin and sweet) are the major type of fruits grown in the middle hills at 1000 - 1500 m altitude which occupies about 16.2 per cent of area under fruits in Nepal. These fruits can be also cultivated in the marginal lands where the returns are declining and are not suitable for present annual crops (APROSC, 1987). Hence, as Table 2 shows, there exists an obvious comparative advantages of increased domestic production of citrus fruits, especially oranges in Nepal that are being imported from India to meet growing demand.

Table 2: Analysis of comparative advantage of selected fruit tree production in Nepal (Economic, Rs/mt).

Fruits	In-country Cost of Production	Packing & Handling	porterage	Net Economic Price of In-country production	Farm gate Econ.Price of Import
Apple	1,763	882	2,500	5,145	10,960
citrus	2,417	1,209	1,250	4,876	11,600
Banana	2,581	1,291	625	4,660	4,600
Mango	3,264	816	625	4,705	9,560

Note: Unit cost of production for fruit trees is based on the total costs and benefits discounted at 15% per annum over the economic life.

Citrus: It includes mandarin and sweet oranges.

Source: East Consultant, 1990

Cultivation of citrus (orange fruits) in the existing hill farming systems is more profitable to dry land anuual crops like maize and wheat and also its promotion is imperative for the import substitution, export promotion (particularly in the market of Northern India) and arresting deteriorating hill economy and natural environment (Anonymous, 1987; APROSC, 1989; East Consultant, 1990). Nepal has a current deficit demand of 12,000 tons of fruits (about 85% of total demand) for local consumption every year. In value term, Nepal imported about 138 million rupees of fresh fruits and about 4.3 million rupees of processed fruit from different countries in 1989-90. It is reported that if present production of fruit remains constant, the gap in demand would increase to 400,000 tons by the year 2005 (Anonymous, 1987). This gap will widen more in the future as the demand for fruits and fruit products is projected to rise with the growth of population and market induced demand (APROSC, 1989).

Initiation of citrus development project in some mid hill districts of Nepal reflects the present government's favorable policy in the promotion of the citrus fruits. Furthermore, it is also preferred fruit as farmers' in the hills have traditionally been growing citrus fruits near homesteads in association with some annual food crops.

1.2.3 Need of Optimum Farm Planning

From the above information it is obvious that citrus fruits are regarded as the important source of farm income for the small farmers in the hill region. Despite this, no detailed and scientific micro-level study as to the actual and potential contribution of citrus integration in existing hill farming systems has been previously been undertaken. Therefore, there exist not much reliable information on the potentiality of integrating this enterprise in improving farm income and welfare of the rural people (EAD, 1992).

Alternative farm plans are imperative in the hills to uplift the present low level of income (Maharjan, 1984). Information on long term farm planning is desirable as presently farmers have not integrated citrus in their existing farming systems with better planning and management. Despite the potential contribution of citrus to farm income, farmers' have not been able to integrate citrus into existing farm systems due to lack of information on the long term benefit of fruit trees, their future market prospects and better technological and information support.

Farm size is assumed to be the major determinant in the hills in integrating citrus in the existing farming systems and consequently the optimum farm plan. The perennial nature of citrus also itself lends appropriate planning since it requires investment for longer period whose returns are obtained only after few years and are spread for throughout their life period.

1.3 Objectives

The main objective of this proposed research is to study existing hill farming systems and analyze the optimum farm plan for integrating citrus, particularly mandarin orange. The specific objectives are outlined below :

1.3.1. To study existing farming systems and identify the major resource availability and their utilization in the study sites.

1.3.2. To analyze the optimal farm plan for the hill farming systems in order to maximize the present value of future income subject to resource constraints and consumption demand.

1.3.3. To examine the economic potentiality of integrating citrus (mandarin orange) when economic environment changed.

1.3.4. To assess the major constraints to integrating citrus fruit in the present hill farming systems.

1.4. Usefulness of the Study

This study will give understanding of existing farming systems and help to identify main constraints and opportunities in improving hill farming systems through optimal multiperiod farm planning. The results of the study will provide the direction for the farmers to improve the efficiency of their limited resource utilization and household income through the use of citrus fruits.

The shadow prices of the resources obtained from this study and sensitivity analysis of the optimal plan will give valuable insights into the relative importance of various resource constraints and about the benefits to be gained by relaxing limiting factors. This study also will highlight impact of policy changes under different alternative economic environments which will be useful for policy makers and planners in formulating policies and guidelines for planning and improving the sustainability of hill farming systems. This research and study approach could possibly be useful for planning and evaluation of similar tree based farming or agroforestry systems which are prevalent in the hills of Nepal.

1.5 Literature Review

Most of the previous studies on the planning and economic analysis in Nepal are biased towards cereal food crops. There are limited scientific and systematic studies dealing with economics of perennial fruit crops and tree based farming systems in the hills of Nepal. Apart from this, there are also limited cases of use of linear programming in farm planning in Nepal, though considering the presence of small farmers and their limited resource endowments, these tools and technique can be successfully used in Nepal for micro level planning and policy analysis (FAO, 1989).

Nair (1984) reported that fruit trees have both distinct socioeconomic value (cash income, nutrition and employment) and environmental merits (soil conservation and ecosystem stability). They are socio-economically more acceptable in comparison with other trees because of their contribution to the cash economy of small farmers (Amyot, 1987; Khaleque, 1987).

Fonzen and Oberholzer (1984) reported that the main improvement strategy for Nepalese hill farms lies in the use of fruit and other multipurpose trees as they are one of the important components of the existing integrated small holder hill farming systems.

APROSC(1989) has conducted feasibility study reports for the viability of the citrus farming projects in the mid-hills of Nepal. It has reported the profitability of the project with economic internal rate of return of 29.36 % . Results of sensitivity tests showed that the citrus farming is economically viable even under adverse situation of (a) cost over run (by 10%) (b) benefit shortfall (by 10 %) (c) a combination of (a) and (b) and (d) delayed project benefits. The financial rate of return for commercial orchard comes to about 29 %.

Gupta and George (1974) used profitability indices for the orange plant whose production life was more than 23 years. The internal rate of return of 29.3 and 45.9% and benefit cost ratio of 1.85 to 2.64 was obtained for orange fruit depending on the size of orange grove .

Eder (1981) also reports from Philippines that peasants experienced a five fold increase in returns to land and about 3.8 times higher returns per unit of labor when they made switch from rice to permanent tree crop like citrus, coconut etc. for the local market.

Due to high return from orange crops more than one third of the sample farmers in the villages of Thanhxuan and Dongphuoc in Mekong Delta of Vietnam converted their part of their paddy fields to orange cultivation (Dung, 1994).

Betters (1988) reported that economic performance measures like Present Net Value, Benefit-Cost Ratio,and Internal Rate of Return can be used to determine the best joint production level for a particular tree - food or agroforestry practice. Once these best combinations have been defined linear programming can be applied using this " best" production combinations as decision variables along with considering wide range of additional constraints.

Linear programming provides effective method for dealing with the allocation of limited resources among the competing activities in determining the farm plan (Heady and Candler, 1958). Mathematical programming (MP) techniques are suitable to consider farming systems in technical, biological and economical sense and to optimize certain aspects. This technique is specially useful to consider the implications of erosion and conservation in whole farming systems and to judge its profitability (Stroosnijder, 1988).

Linear programming for permanent agriculture can become more realistic by incorporating time dimension in the model. Dynamic linear programming (DLP) is a model which can overcome many of the limitations of the stationary equilibrium approach of modeling investment decision (Hazell and Norton, 1986).

Loftsgard and Heady (1959), applied DLP model to solve optimum plans for eight series of years where productivity of resources in the farm business were related to expenditure needs of farm family in Iowa.

Similarly, the DLP was also employed by Dean and Benedicts (1964) to derive normative development plans through time for small land reform farms in the newly irrigated Metaponto Plain Southern Italy. The analysis indicated great potential for internal saving and investment by farm families and therefore rapid development possibilities for intensive fruit (oranges, peaches and grapes) and vegetable cultivation.

Dynamic modeling of farmer's decision making was employed by Rosegrant and Herdt (1980) in order to simulate the impacts of credit policy and fertilizer subsidy in Central Luzon, Philippines. The model incorporates stochastic production relationship and dual credit market situation. Three policies were evaluated in the model solution which showed that credit and fertilizer policies could increase yield by 21-30%.

The use of multiperiod programming can increase the scope and accuracy of farm management and planning analysis; it can provide a more accurate representation of the time related production cconditions that are characteristics of agriculture in most of the developing countries of the world (Crawford *et al.*, 1977).

Shaky and Leuschner (1990) developed a multiple objective linear programming (MOLP) model which could generate technically efficient land use plans by using data from Phewa Tal Catchment, Pokhara, Nepal. The farms in this area practised integrated agricultural system embodying crops livestock and forestry. A five year planning period and 25 year planning horizon were chosen.

Yaha, Wiboonpongse and Sriboonchitta (1991) used multiperiod linear programming model for Planning Conservation Farming Systems for the Highlands of Chiangmai Province. The results showed that off-farm income is important for expanding permanent farming systems in the Highlands.

CHAPTER II

METHODOLOGY

2.1 Scope of the study

This study has mainly focussed on long term planning of hill farming systems taking into considerations of household resources and constraints. Since planning of perennial tree crop is complicated and dynamic because of time dimension involved in production, heterogeneity in resource use and intertemporal profit maximization, it includes the study of only one type of citrus fruits that is mandarin orange.

Considering the size, complexity and planning horizon of the multiperiod model, the study includes risk neutrality condition. However, the risk averse behaviors of the farmers will be accounted through sensitivity analysis by taking higher discount and interest rate, lower output and price rate. In addition to this, by maximizing net cash income under the conditions of satisfying household subsistence requirements from crops grown a major aspect of risk reduction will be accounted for (Emana and Storck, 1992). In order to capture the economic life of citrus fruit and to make multiperiod plan more realistic the planning horizon has been assumed to be twenty years in which, total period is divided into period of yearly intervals.

2.2. Data collection

2.2.1 Informal Survey

Reconnaissance field visit was conducted to appraise different sites and select the appropriate study sites for this study. Rapid Rural and Participatory Rural Appraisal was the main tool for the informal survey followed in understanding farming systems, indigenous practices, biophysical and socioeconomic circumstances, available resources, problems and general situation of the study areas. Matrix ranking (PRA) was done in the study site to know the preference of farm households for different enterprises and their potentiality in the existing systems.

2.2.2 Formal Survey

The information from informal survey was employed to proceed for formal survey. The field survey methodology consisted of a household survey and pretested questionnaire interview of the head of the households. The study was conducted in the relatively accessible but suitable areas for growing citrus fruits in two study sites of Kavre district, central mid hill region, Nepal. The two study sites were, Patlekhet and Sankhu village development councils (VDC's) of Kavre district. These area were selected because of the following reasons. 1) The study site I (Patlekhet), represents the true mid hill region of Nepal in respect of altitude, topography and climatic setting where soil fertility deterioration and erosion problems are most common. The study site II (Sankhu), also is true to many mid- hill region but is different in terms of farming systems where citrus fruit particularly mandarin orange has been successfully integrated by the farmers into their existing crop based systems. 2) These areas are relatively accessible by roads and markets, therefore, they have potentiality for expanding citrus production in the future. 3) The limited time of the study period and budget constraints did not allow researcher to take up field survey in the more potential yet successfully areas of other mid hill region.

Survey of the randomly sampled (n= 125) households from two village development councils: Sankhu and Patlekhet was conducted with the assistance from local resource persons in each study site. The field survey was combined and verified with participant observation and group discussion with local key informants and sampled households.

Finally, the size of sample remained 123 after omitting two incomplete samples from patlekhet site. The secondary source of bio-physical and socioeconomic data were combined with participatory field observation and field questionnaire survey in analyzing and describing different components of farming systems.

2.3 Method of Data Analysis

2.3.1. Descriptive Statistics

Descriptive statistics have been used to analyze resource base and describing farming systems of the study areas and also to assess the major constraints to integrating citrus into the existing hill farming systems.

2.3.2. Classification of Sampled farm households

In this study farm planning over time, policy and resource supply analysis have been done by classifying sampled farmers into four different homogenous groups based on the farm size: group I (marginal), group II (small), group III (medium) and group IV (large). There fore, input-output coefficients and resource endowments of each group were estimated differently for each group.

Table 3 Classification of sampled farms into different farm sizes

Groups	Farm Size Range (hectare)	No of farms		Average farm size(ha.)	
		Patlekhet	Sankhu	Patlekhet	Sankhu
I	0.05-<0.5	13	11	0.308	0.331
II	0.50-<1.0	23	21	0.860	0.778
III	1.00-<2.0	17	18	1.330	1.336
IV	> 2.00	10	10	2.054	2.304
		(N = 63)	(N = 60)		

2.4 Model Formulation

The basic analytical technique used in the planning process of this study is a farm level multiperiod linear programming model (MLP), which is expressed mathematically in the following form (Rae, 1987).

$$\text{Max. } P = \sum_{i=1}^{m} GM_{j1} Y_{j1} + \sum_{i=1}^{m} GM_{j2} Y_{j2} + \ldots + \ldots \sum_{i=1}^{m} GM_{jT} Y_{jT} \quad \ldots\ldots(1)$$

Subject to,

$$\sum_{i=1}^{m} A_{ij1} Y_{j1} \leq X_{i1}, \quad i = K+1, k+2, \ldots n$$

$$\sum_{i=1}^{m} A_{ij2} Y_{j1} + \sum_{i=1}^{m} A_{ij2} Y_{j2} \quad \leq X_{i2}$$

$$\vdots$$

$$\sum_{i=1}^{m} A_{ijT} Y_{j1} + \sum_{i=1}^{m} A_{ijT} Y_{j2} + \ldots + \sum_{i=1}^{m} A_{ijT} Y_{jT} \leq X_{iT}$$

$$Y_{jT} \geq 0, \; j = 1, 2, \ldots m;$$

$$t = 1, 2, \ldots, T.$$

Where,

P = present net value (PNV) of total gross margin,

Y_{jT} = level at which activity Y_j is initiated in year t;

GM_{jT} = the gross margin (present net value) per unit of activity Y_j initiated in period t:

X_{iT} = supply of the resources i, in period t; and

A_{ijT} = per unit requirement of activity Y_j for resource X_i in period t.

During the initial time period (t=1) resources will be required by activities initiated at that time; during the second time period (t=2), resources might be allocated amongst the activities in the second period time plus those already initiated during the first time period, and so until the real time period (t=T) is reached , when period T resources might be required by activities initiated at that time plus all previously initiated activities.

The main objective of the model is to maximize present value of future income (gross margin) subject to resource constraints and consumption requirements. Any LP model is basically composed of three components: an objective function, activities and constraint sets. The model has been formulated for a planning horizon of twenty years with yearly interval as periods to incorporate dynamic, complex and semi-subsistence nature of hill farming systems by taking into consideration of economic life span of orange trees. Therefore, in this case, while formulating models, resource supplies, activities and input-output coefficients are dated and built based on the growth and productivity of orange in different years.

Activities and constraints are included in each period for all the relevant decisions and many of these, particularly the activities of annual crops have been duplicated from one period to the next. On the other hand consumption is modelled to differ from one to other period depending on the levels of income and family size. Models have been applied for four representative farms constructed by farm size.

Appraisal of the existing systems were done based on how resources are being utilized and what are the incomes obtained from various enterprises adopted by different size of the farms. With in the frame work of the resource restrictions and keeping in view of the weaknesses of the existing systems and possibilities of incorporating new technologies, alternative farm plans have been developed based on long term farm income and consumption demand of the households.

Sensitivity analysis has been done to examine the suitability of the optimal farm plan with citrus integration when economic and other conditions changed. This post-optimality analysis has covered the effect of various changes in output prices, wage rate, credit interest rate and discount factor of net present value of income to the optimum plan and production level.

There are four major factors considered in the formulation of MLP model for the economic evaluation of hill farm systems (Figure 1).

1. Human factors: Farmers' goals of maximizing of farm income after satisfying their minimum consumption requirements.
2. Resource factors: The availability of labor (peak and off-season), land and capital constraints are considered in this factors.
3. Technological factors: The yields of crop output and activities, labor

and non labor inputs (seeds and fertilizers etc.) are included in this factors.

3. Market factors: Input and output prices, and hired human labor and bullock labor wages are included in this category.

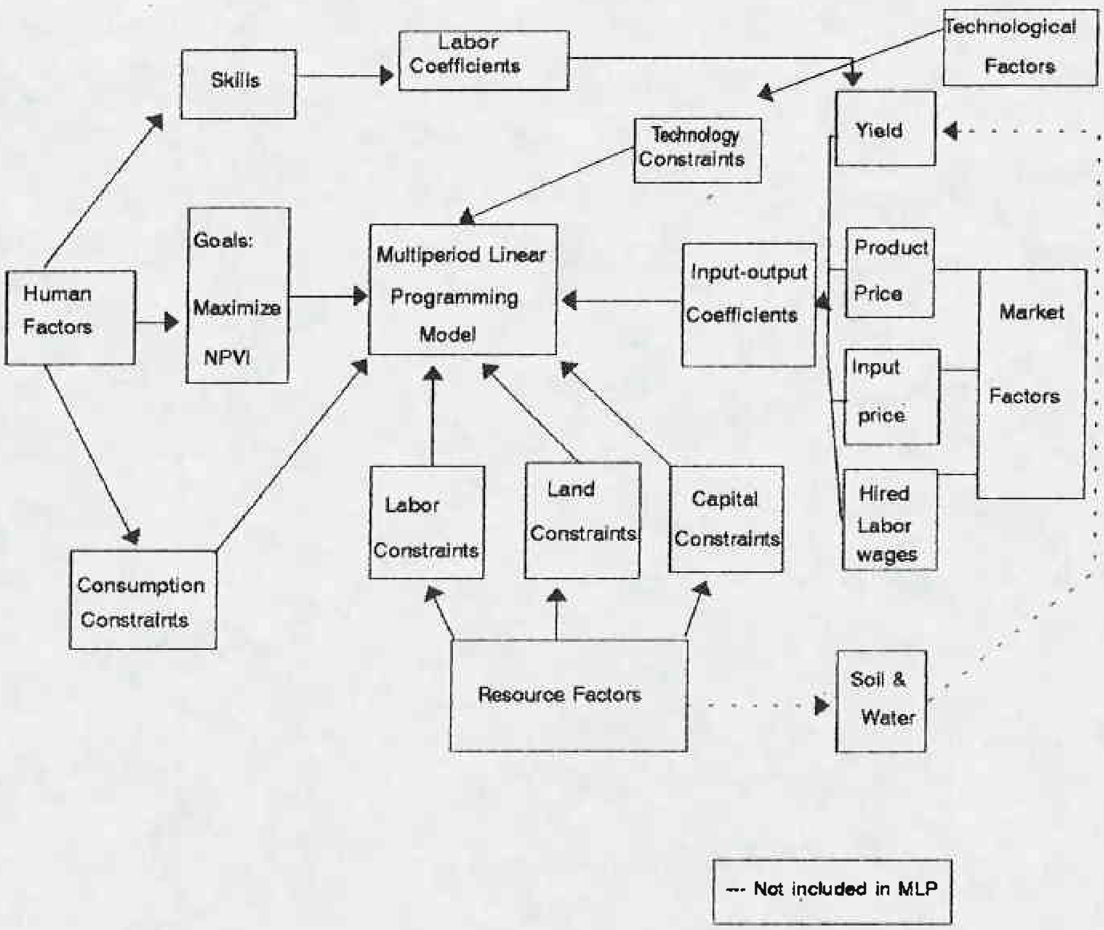

Figure 1. Framework for Multiperiod Linear Programming (MLP) Model for Nepalese Hill Farms

2.4.1 Objective Function

The main objective of the model is to maximize net present value of gross margin or income (NPVI) subject to land, labor, credit constraints through improved resource use planning after fulfilling their basic consumption requirements. This is a reasonable assumption since in a semi-subsistence economy such as the case of middle hills of Nepal, the primary objective of the small farm households is often to allocate resources to provide basic consumption requirements. The cash surplus or resources which is left over after meeting household consumption and expenditure requirements, are only then invested or used to generate cash income as higher net income provides them the means of satisfying many of their wants. In the other words, basically this model is a multiobjective and multiperiod programming model in the sense that one goal that is present value of future income is maximized and the remaining goal (basic consumption requirement) is specified as inequality constraint (Hazel and Norton, 1986).

2.4.2 Decision Variables

There are ten basic decision variables each representing different alternative annual crops and perennial fruit tree (citrus) production, and other farm and off-farm related activities.

2.4.2.1 Production Activities

The production activities include alternative annual and perennial crops activities such as rice, wheat, maize, mustard and orange which are mainly grown in the study sites. The average gross margins, cash used and labor use per each activity for a given land unit are used as the coefficients in the model. The following crop production activities are included in the MLP algorithm.

a. Rice production activity b. Wheat production activity c. Maize production activity d. Mustard production activity e. Mandarin orange production activity.

2.4.2.2 Off-farm Activities

All activities performed by farm households outside the traditional agricultural activities are included in the off-farm (labor wage) activities. The off-farm activities which are mentioned in this study include both farm wage labor and non farm activities. Since, farmers in the study areas work in different sorts of wage labor, and off-farm activities, the provision has been made in the model for the farmers to go for off-farm activities. The average labor wage coefficients of off-farm activities like farm labor, portering (milk and other goods), skilled labor (carpentry, construction worker) and other side line activities were included in the construction of MLP algorithm .

2.4.2.3 Labor Hiring Activities

Farmers, in the study areas hire labor during peak season of farming (June, July, and middle of November to middle of December). Hired labor for both male and female are available during peak seasons when family labor is not enough to carry out field operations. The coefficient for labor hiring activity is used in the matrix from prevailing market wage rate of the study areas.

2.4.2.4 Capital Transfer Activities

The cash surplus which is difference between (a)total net cash income of the previous year and (b)fixed costs and household withdrawals on consumption expenditure of the previous year is automatically transferred to the following year in the programming operation by including household expenditure and transfer of capital between the year. The activity produced in the kth year has a positive coefficients in the capital equation for year k, but has a negative coefficients in the capital equations for the k+1. However, in the first year of the investment, cash transfer row is negative assuming farmers have zero saving as the return from the existing crop based systems in the study areas do not provide enough income to save for future investment.

2.4.2.5 Capital Borrowing Activity (credit)

Since farmers own fund is not sufficient for investing and meeting farm operating costs in citrus fruits, credit borrowing provision is made in the model. According to discussion with the personnel from agricultural development bank (ADB/Nepal) and fruit growing farmers in the area, farmers can borrow money for their fruit cultivation and meeting other farm expenditure. Capital borrowed has to be paid within 10 years with the interest rate of 16% for fruit trees. The farmers have to pay only interest during the first five years period and repay principles and interest during the second five year period when they can get return from citrus fruits.

2.4.2.6 Household Consumption and Expenditure Activity

Survey of farm households reveals that majority of the farmers grow crops to satisfy their household consumption and expenditure requirements. After meeting the subsistence consumption requirements only farmer go for such activities which maximizes their net income. Therefore, provision has been made in the MLP algorithm to include the basic consumption (food, cloth, medicine and ceremony) requirement and expenditure which depends on household income and growth of family size. The details of this activity is elaborated in 2.4.3.3 .

2.4.3 Resource Constraints

2.4.3.1 Land Constraints

Land in this study is treated as homogenous resources in terms of fertility, water supply, and suitability for fruit trees and field crops. Additional land rental (in or out) is not allowed as it is not a common practice in the study area. Maximum availability of land in each period is limited to average amount of land owned by the different groups of farmers respectively.

2.4.3.2 Family Labor

Numbers of family agricultural laborers available per man-day per year for both peak and off-season have been used to represent labor availability coefficients. Children above 15 years old and 1.25 women days are considered equivalent to one male adult. Labor taken on exchange basis has been considered as family labor since farm family do not spend cash or kind for this labor. While calculating the supply of family labor 8 hours of day is considered as one man day.

The estimation of family labor availability over planning period is based on the average growth age of family members and the growth rate of population per year over the past years. Labor restriction was imposed both for the peak and off-season of the farming.

2.4.3.3 Capital Constraints

Farm operating costs are specifically used as capital in this model. Cash saving transferred from the previous year has been considered as the sources of capital. But the once cash saving was zero or insufficient then the model was designed to borrow capital to cover the farm operating costs. The capital coefficients in mandarin orange become negative until 5th year as it does not furnish capital surplus until this time.

2.4.3.4 Consumption Constraints

Average farmers in the study areas have some monetary objective and some subsistence objectives and therefore production and consumption decisions are interrelated. Consumption expenditure is modelled differently for different group of farmers based on the income and growth of household size over the planning horizon. The household consumption and expenditure includes expenditure on food basic needs, cloth, education, medical treatment and ceremony expenses.

$C = \alpha + \beta Y$

C = total consumption expenditure/family

Y = family gross income

α = the average of basic needs consumption expense /family

β = marginal propensity to consume

Econometric methods namely ordinary least square (OLS) is used to solve the above model and linear restriction is imposed to the constant term α, in the above equation by using average of basic need consumption which is estimated through survey and minimum calorie requirements for an adult per annum. Therefore, the basic need consumption is a predetermined variable in the model. The standard percapita minimum requirement of calorie for an adult in the hills of Nepal has been estimated to be 2250 k cal per day (EAD, 1984).

2.4.4 Programming Softwares for Data Analysis

Since the model size of multiperiod programming was very large, it was impossible to write and run directly in LP softwares. Therefore, firstly, Quattro Pro3 was utilized to build the matrix and then the Equation program of SARA (Spread sheet Assisted Resource Analysis) was utilized to transform and translate the detached input-output coefficients matrix in the worksheet into linear equation (Scott, 1991). Similarly, the constraints and objective function equations are constructed in Dos Editor program and combined to the equation file through DOS Copy command. Finally, this full combined model file is run in HYPER LINDO (Linear Interactive and Discrete Optimizer) package (Scharge, 1991). The final output solutions are summarized by Report and Table sub program of SARA program.

CHAPTER III

RESOURCE BASE AND FARMING SYSTEMS

This chapter deals with the general charecteristics of the study areas, their resource bases (natural and human) and it analyzes the existing farming systems. It also covers the analysis of farm and off-farm income and the cost and return of both crop and citrus based systems of the study sites in the middle hills of Nepal.

3.1 RESOURCE BASE

3.1.1 General Characteristics

Patlekhet and Sankhu village development councils (VDC's) are located in Kavre district, central middle mountain physiographic region, approximately 55 and 50 km east of Kathmandu respectively, the capital city of Nepal. These two study sites are very close to each other and are separated by a ridge of mountain which consists of Namobudha temple an important religious place for the Budhists.

Patlekhet VDC (the study site I) lies south western part of the Jikhikhola watershed and about 1.0 hour walk towards south direction from Dhulikhel, the headquarter of Kavre district. With in the Patlekhet VDC,

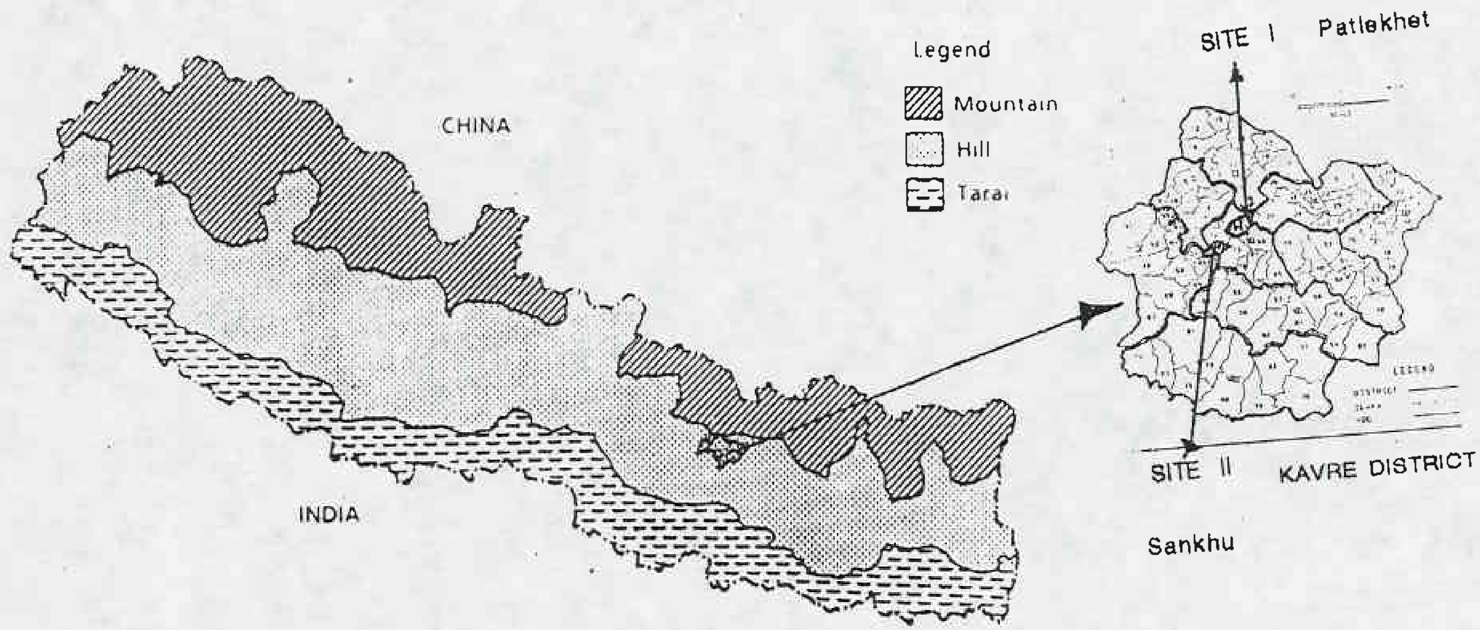

Figure 2 Agroecological Regions of Nepal

the study site covered 5 wards namely 1,5,6,7,8, consisting of small scattered villages: located towards south-west side of Patlekhet adjoining to Phulbari VDC. The aspect of the site is generally north east facing. Soils are loamy to sandy loam. Patches of red soils are also common. The altitude ranges from 800m - 1700m above the mean sea level.

Sankhu VDC (the study site II) is located 5km east of Banepa town adjoining to Sharada Batase, Sunthan and Khopasi VDCs' of Kavre district. The site in general has moderate slope with south facing aspect. The altitude ranges approximately from 1300 to 1600 m above mean sea level. Soils are loamy to sandy loam with good drainage. This site is unique to whole Kavre district and also probably to many mid hill regions of Nepal because of its highly successful citrus dominated farming systems.

The climate of the both Patlekhet and Sankhu are almost similar. However, Patlekhet is relatively cooler even in the same altitude, since the aspect of the village is generally north east facing towards the Himalaya. As observed from nearest meteorological station at Balua, Jikhikhola watershed, Kavre the climate of the area is warm temperate ranging from minimum of 7 degree celsius (December -January) to 30 degree celsius (April- September). The annual average precipitation is about 1300 mm which is mainly distributed during June to September (Appendix Figure 1). Winter months are dry and relatively cool in both the study sites. Within the area also a lot of variations is observed in temperature due to topography and aspect.

3.1.2 Natural Resource Base

3.1.2.1 Farmland Resource

As common to many mid-hill region of Nepal, there were two distinct land use patterns practiced by farm households in both the study sites: Irrigated Paddy land (Khet) and rainfed upland (Bari). However, some farmers (28.8%) also found to own some forest and pasture land (Pakho land) in the Sankhu study site. Among the land types, the size of rainfed upland (Bariland) was larger and the most common type in all farm households. About 99% of the sampled households in both the study sites own upland where as 20% households are reported to have no paddy land (Khetland). The area under cultivation was 17.92 % paddy land and 45.62 % upland in Patlekhert. However in Sankhu 66% of the area is under upland. There were some patches of upland in Patlekhet where rice could be cultivated in monsoon rains and depending upon the availability of water.

Citrus orchard occupied considerable area in Sankhu site. The cultivation of citrus was mostly done in rainfed upland. Citrus orchard of varying size ranging from 0.06 - 4.2 hectare were found in Sankhu site. Size of orchard and number of citrus trees were related. The percentage area under fruit tree to total holding was highest in group I (marginal) farms as compared with large farms (Table 4). About 90% sampled households at Sankhu have integrated orange tree into the existing systems.

Table 4 : Land endowments (hectare) in sampled farm households

Groups	Paddy land (Khet land)	Rainfed Upland (Bari land)	Orchard	Total Land	No. of farms
Patlekhet					
I	0.103	0.205	-	0.308	13
II	0.375	0.485	-	0.860	23
III	0.355	0.975	-	1.330	17
IV	0.854	1.200	-	2.054	10
Mean	0.422	0.716	-	1.130	-
Sankhu					
I	0.103	0.076	0.151	0.331	11
II	0.341	0.226	0.210	0.778	21
III	0.512	0.477	0.341	1.336	18
IV	0.852	1.100	0.382	2.304	10
Mean	0.452	0.470	0.271	1.187	-

Source : Household survey , 1993

Table 5. Average number of fruit trees in sampled households

Farm type	Size of Orange grove (ha.)	% of area under Orange	Average No of trees		
			NB	FB	Total
Group I	0.15	45.62	40.71	96.5	137.2
Group II	0.20	27.05	93.77	128.9	222.26
Group III	0.34	25.56	103.26	146.70	249.96
Group IV	0.38	16.35	190.66	333.75	524.41
Mean	0.27	28.64	107.10	176.46	283.56

Note: NB = Non bearing; FB = Full bearing
Source: Household survey, 1993

The average farm size varied from 0.30 hectare in group I farm to 2.05 hectare in group IV farm in Patlekhet and 0.33 hectare in group I (marginal farm) to 2.30 hectare in group IV (large farm) at Sankhu site (Table 4).

3.1.2.2. Livestock

On an average a household in the study site I (Patlekhet) keeps 2.06 animals. Similarly, in the study site II (Sankhu) a house hold keeps about 2.10 animals. The rearing of milch animals mostly buffalo and cows are most common in both the study sites. The analysis of the data on livestock unit showed a positive relationship between the intensity of land use and number of livestock unit. On an average 30% of the sampled farm household owned a pair of bullocks in the study sites. Livestock raising not only provides draft power and the organic manure for the farms and the nutritious food to the farm family but also helps to augment and stabilize farm income in the study areas.

3.1.2.3. Forest and Pasture land

Forest of pine plantations and some patches of natural forests are common in both the study sites. The distance from farm to forests is relatively short as compared to many parts of the middle hills of Nepal. Apart from distinct forests land forest trees are also found grown in farm land and community land (scrub land and stream banks) adjoining to farm areas. Farmers have responded the scarcity of the fodder, firewood and timber by planting the trees in the farm land since farm households presently do not have access to forest. In both Patlekhet and Sankhu sites the major species observed in such land were *Alnus nepalensis, Melia ajadiracha, Choeriaspondis spp.* etc.

3.1.2.4 Water Resources

Since the study villages in Patlekhet lies between Nauchale and Satpatre minicatchment within Jikhikhola watershed, they provide fairly enough source of water for drinking, domestic use and to some extent irrigating few parcels of land during rainy season when water is enough in the streams. In Sankhu site, Ghattekhola on the east side of the village on the way to Namobudha temple, and Andheri and Sundi khola are the three streams used as the major sources of water for rice crops, drinking and domestic uses.

3.1.3. Human Resource Base

3.1.3.1 Ethnicity

The main ethnic groups of both study sites are Brahmin and Tamang. However, small number of other ethnic groups: Newar, Chhetrias, Bishwokarma were also present in the study sites. Brahmin and Tamang constitute about 50% and 30% of the total sampled households respectively.

The literacy rate was found higher in Brahmin than Tamang ethnic (Tibeto-Burmese origin) group. The major source of off-farm income for Brahmin group came from working as village priests while in Tamang it was mainly from wage labor in Patlekhet and trekking guide and portering in Sankhu site.

3.1.3.2 Family Composition and Labor force

The average family size of the sampled household ranges from 5.48 in farm group I to 9.00 in farm group IV at Patlekhet, where as in Sankhu it ranged from 6.1 in group I to 7.8 in group IV in Sankhu. This indicates that family size and thereby labor force increases with farm size. However, the man land ratio was found very high in group I farms both in Patlekhet and Sankhu site which decreases with increase in farm size (Table 6, and 7). This suggests a likely situation of excess population pressure on land and also the labor supply on all the farms.

3.1.3.3 Education Status

The average literacy rate in all farm group was relatively higher in Sankhu site as compared with Patlekhet site. The literacy rate is lower in smaller farm group in comparison with medium and larger farms in both the sites (Table 6 and 7). Large farm households (group IV) in both the sites have 100% literacy rate and the average literacy rate among different farm groups was above 80% which is very high as compared to national average rate of 36% (CBS, 1991).

3.1.3.4. Economically Active Memebers

The average number of economically active members which are involved both in farm and off-farm per household ranges from 3.4 to 4.8 in Patlekhet and 3.22 to 4.2 in Sankhu. Among farm groups, dependency ratio was found highest in group IV (large farm) and group III (medium farm) in Patlekhet and Sankhu respectively .

The information on family size, man-land ratio, average age of respondent household head, average labor force/ household involved in farming and total man days involved in off-farm activities are presented in the Table 6 and 7. Family size and average labor force were found related with farm size in both the study areas. Man-land ratio was found negatively related with farm size.

Table 6. Demographic Features of Sample Households at Patlekhet Site

Demographic Features	Group I	Group II	Group III	Group IV	Mean
Respondent's age	40.60	44.82	43.80	35.80	41.25
Literacy Rate	44.00	41.10	69.23	100.00	82.15
Family Size	5.48	7.21	8.10	9.00	7.44
No of Dependents	1.96	3.11	3.66	4.20	3.23
EAM (No.)	3.40	4.12	4.37	4.80	5.22
ALF (No)	2.56	2.96	3.40	4.20	3.28
MLR	17.79	8.38	6.09	4.38	6.58
MOF	334.00	374.00	410.00	448.00	391.50

Note: EAM = Economically active member; ALF = Actual labor force in farming; MOF = Man days in off-farm (off-season) ; MLR = Man land ratio in hectare

Table 7. Demographic Features of Sample Households at Sankhu Site

Demographic Features	Group I	Group II	Group III	Group IV	Mean
Respondent's Age	46.22	43.89	43.46	57.60	47.79
Literacy Rate	55.55	89.28	100.00	100.00	86.20
Family Size	6.11	7.48	7.93	7.80	7.33
No of Dependents	2.88	3.36	4.26	3.60	3.52
EAM (No.)	3.22	4.28	3.73	4.20	3.80
ALF (No.)	2.66	2.77	2.88	3.20	2.87
MLR	18.45	9.61	5.93	3.38	6.17
MOF	264.00	343.00	385.00	397.00	347.25

Note: EAM = Economically active member; ALF = Actual labor force in farming; MOF = Man days in off-farm ; MLR = Man land ratio in hectare

Source: Household Survey, 1993

3.1.3.5. Labor Endowment

The average number of labor force availability per household was higher in Patlekhet (3.28) as compared to Sankhu site (2.87). However, labor availability both in the peak season (June, July, middle of November to middle of December) and off- season (the rest of the months included other than in peak season) was found related with the farm size (Table 8).

This happens because many of the sampled large farm households have extended family systems. The total labor availability for each season (peak and off-season) is estimated from each household considering 8 hours working day as one man day. From each adult labor force, 26 man days per month is available which is used for calculation of labor coefficients.

Table 8. Average labor availability (man day) per household by seasons.

Farm groups	Family size	Labor force in farming	Family labor man day /season		
	(No.)	(No.)	Peak	Slack	Total
a.Patlekhet					
I	5.48	2.56	200	599	799
II	7.21	2.96	231	693	924
III	8.10	3.40	265	795	1060
IV	9.00	4.29	335	1003	1338
Average	7.44	3.28	258	773	1031
b. Sankhu					
I	6.11	2.66	207	622	829
II	7.48	2.77	216	648	864
III	7.93	2.88	225	674	899
IV	7.80	3.20	250	749	999
Average	7.33	2.87	320	673	898

Source: Household Survey, 1993

3.1.3.6 Capital Endowment

Operating capital was a limiting factor particularly for households in Patlekhet site. However, for households in the Sankhu site, the revenue obtained from citrus was fairly sufficient for meeting expenditures requirements and further investment on citrus. Capital comes mainly through own saving, and non institutional sources such as farmers' relatives and local merchants. The interest rate charged by local merchants for the borrowed fund varied from about 24% to 39% per annum in both the study areas. Credit from institutional sources which mainly includes agricultural development bank and other commercial banks is not so common among sampled households. Cash used in crop production increased with the farm size. However, there was not so much variation in the cash used in the two different sites (Table 9).

Table 9. Cash (input) costs / hectare for crops by farm size

	Cash (input) used in different farm groups(NRs/ha.)				
crops	I	II	III	IV	Mean
a.Patlekhet					
Rice	4400	4000	5000	9000	5600
Wheat	3000	3700	6000	7600	5075
Corn	5000	7000	8200	10000	7550
Mustard	1800	2400	3000	3000	2550
b.Sankhu					
Rice	4120	4320	5320	9180	5715
Wheat	3160	3700	6680	8500	5510
Corn	4380	7160	7900	10580	7505
Mustard	1840	2600	2840	3540	2705

Source: Household survey, 1993

3.2. EXISTING FARMING SYSTEMS OF THE STUDY AREAS

Two types of farming systems prevalent in two study sites of Kavre district as given below are studied and analyzed:

1. Annual Crop- Based Systems of study site I (Patlekhet VDC).
2. Citrus - Based Systems of study site II (Sankhu VDC).

3.2.1. Annual Crop- Based Systems

This type of production system, which is also common to many mid-hill regions, is prevalent in Patlekhet VDC. The landscape of the site is undulating and maize based rainfed production system (bari land) is practiced in numerous carved hill terraces.

However, medium and large farmers also have paddy land (Khet) far away from their houses. The major cropping pattern in the upland (Bari) is maize followed by wheat, mustard or mixture of wheat and mustard or Rapeseed, where as in the paddy land (khet) paddy followed by wheat/fallow. It was commonly observed that in the maize- based rainfed uplands farmers have practice of mixing mustard/rapeseed (Brassica spp.) with wheat probably as insurance in the event that the wheat crop performs poorly.

Farmers have increased the cropping intensity in the upland due to increasing population pressure. The low and highly variable production of annual crops in upland due to irregular rainfall and decline in soil fertlity have been mitigated to some extent by the use of chemical fertilizers. Thus, presently farmers tend to use more of purchased chemical fertilizers (> 40 kg of plant nutrients) in the upland to restore original fertility which is higher than national average use of 27.4 kg (FAO, 1992).

However, increased price of chemical fertilizers and deteriorating soil fertility due to intensive cultivation and soil erosion have declined return from traditional crop production and farming has become no more remunerative in the upland as before. On the other hand due to lack of technological information and extension support farmers have not been able to integrate citrus in their existing systems.

3.2.1.1 Economics of Crop production

Returns to major farm resources such as labor and capital vary in accordance with the productivity, price, labor and input requirements of the enterprises. However, the return (gross margin) from major upland crops maize and wheat is very low as compared with rice and mustard (Table 10). The low return is because of the declining productivity of these crops over the years despite their relatively higher use of labor and chemical fertilization for its cultivation.

Table 10. Economics of crop production systems

(Mean of four farm groups NRs./ha.)

Particulars	Rice	Corn	Wheat	Mustard
Yield (kg/ha.)	2912	1702	1625	607
Price (NRs.)	8.5	5	4.5	16
Gross value	24752	8510	7312	9712
Variable costs(input)	5600	7550	5075	2550
Gross margin	19596	960	2237	7160
Hired labor costs	2806	750	1125	1570
Labor use(M day/ha.)	217	182	115	77

Source: Computed from survey, 1993

3.2.2. Citrus- Based Systems

3.2.2.1 Flow and linkages among Citrus Based Farming systems

Farming systems of the study site II at Shankhu VDC is citrus based and covers a broad spectrum of land use, crop, cultural and ownership situation of livestock including various off-farm activities that a farmer perform for his living.

Annual crops, fruit (orange) trees, and livestock have been identified as the most important components of the farming systems in the study site II at Sankhu. A farmer or household manoeuvres these three components with his management skills in order to extract outputs that can be generated from each type of sub- systems. Various outputs have been generated as a result of the integration of different components of the farming systems. Some of the outputs obtained from one component have been used in other components in the form of inputs for deriving outputs from the latter and vice versa. Market forces play important role in shaping the farming systems. There is strong linkages among citrus, crops and livestock sectors through market. The cash income obtained from the fruit sale is utilized for buying chemical fertilizers for crop production and purchasing livestock feeds. Also, the farm household use this cash income obtained from fruit sale in hiring labor during peak seasons of farming. Apart from this citrus, annual crops and livestock activities are supportive among each other since livestock provides manure (compost) and orchard and crops provide fodder and forage for livestock. So there is a very good interaction of citrus fruit with the production of other components of the systems.

Citrus production is complementary to existing systems since its cultural requirements do not compete with planting and harvesting operations of food crops. Cultural operations for the citrus (orange tree) could be extended during slack period in the early summer months to avoid peak labor demands periods during which opportunity costs and market prices for labor tend to be higher. However, there is some competition between food crops and citrus for nutrients, moisture and labor management activities during early stages when intercropping of food crops is done between citrus trees. Improved dwarf varieties have less competition effect on crops because of lower canopy.

Small scale farmers who do not have sufficient extra land to grow food crops generally have a tendency to intercrop in between fruit trees during prebearing stages to meet their subsistence food and consumption requirements. Maize during summer season and mustard and wheat are common during winter season. Unlike the most of the other parts of the midhills, the forestry sector is loosely linked in Sankhu site, which can be attributed to the strong market integration of the citrus based farming system of the study area.

Cropping patterns in this village are usually orange/ maize- based in the rainfed uplands (Barilands) and paddy- based in the irrigated lands (Khet). Paddy is the major crop in the irrigated land (khet) followed by wheat while maize, mustard citrus mainly mandarin orange are the dominant crops in uplands (Bari and Pakho).

3.2.2.2 Relationships between Farm Enterprises and Farm Resources

Farming in the study area as mentioned above includes various enterprises such as citrus orchard, upland crops (maize, wheat, mustard), lowland rice and livestock. In order to have farming systems understanding and the farmers' decisions regarding land allocation and crop management (mainly input use) for orange, a correlation analysis is carried out. First the analysis covers the relationship that exists among various farm enterprises e.g. upland crops, orange trees, lowland rice and livestock and their possible relationship between these and such general farm characteristics as farm area, family size, family income, and family labor which are used to indicate farm resources.

Table 11 Relationship between farm enterprises and farm resources for farm group I (Pearson correlation analysis) in Sankhu

Farm resources	Farm enterprises			
	orange	corn	rice	livestock
Farm size	0.4548	0.43	0.664	0.8394
Family size	0.0092	0.58	0.833	0.3693
Family labor	0.3203	0.01	0.552	0.0375
Family income	0.7290	0.01	0.080	0.1025

The relationship between crop size area or size of land allocated to these components and farm resources (farm size, family income, family labor) show the dominant resource allocation (Table 11). The data indicated that the correlation between the area planted with citrus or other crops and farm resources was positive. The positive relationship was found stronger with the farm size and area under orange, rice and livestock holding. Similarly, strong positive relationships existed between rice area and family size and family labor.

3.2.2.3 Comparative Economics of Orange and Traditional Crop Production

Mandarin orange (*Citrus reticulata*) is an important citrus fruit most commonly grown in the mid-hills region of Nepal. It is rich in vitamin `C' and other nutrients which are essential for human body maintenance and growth. The production of perennial crop such as orange involves planting, removal, yield and time dimension not similarly encountered in annual crops which is distinguished from the production of annual crops by; (i) The long gestation period between initial input and first output. (ii) An extended period of output owing the initial production or investment decision. (iii) Eventually a gradual decline of the prodcution capacity of the plant after certain years.

Thus the economics of orange production must consider the lags between input and the output and the effects of population in bearing plants on production. The per unit yield of orange varies with the age of bearing plants, with technology (varieties, cultural techniques), weather and biological factors. In some cases current yields may also be related to past yields by alternate bearing tendencies and conceivably varied in response to current profit expectations and primarily by more complete and careful harvesting practices.

Costs and return analysis of orange in this study has been done based on the input-output coefficients for existing orange production. The unit of analysis is in per tree basis and later it is converted into per hectare. While comparing the annual and orange crop combinations the per year net returns of orange is worked out and compared with the per year net returns of annual crops to have equal time dimension of comparison. Similarly the different (unequal) costs patterns of the orange in the year of gestation is averaged and compared on per year basis with the equal cost patterns of the annual crops.

The results of the cost return analysis (Table 12) indicates that compared to maize and wheat, the crops like orange and rice are profitable under present systems of production.

Table 12. Comparative economics of orange and traditional crop production (NRs/ hectare)

(Mean of four different farm groups)

Particulars	Orange	Rice	Wheat	Corn	Mustard
Yield (kg/ha.)	10240	2970	1640	1770	662
Price (NRs./kg)	7.00	9.00	4.50	5.00	16.00
Gross return	10355	6729	2128	3047	3142
Gross margin	8028	5448	1031	2824	2371
Variable costs	2327	1280	1096	2122	770
Hired labor costs	725	950	895	890	505
Labor use(M day/ha.)	161	211	111	157	69

Notes: Above economic parameters were calculated based on 20 years of economic life for orange and 16% discount rate for all crop activities. Therefore costs and return data are in net present value (NPV).

Source: Computed from survey, 1993

The analysis shows that return from orange is fairly high indicating the profitability of the enterprise, despite its relatively low total labor use per unit of land as compared with the existing annual crop rice. The total man days of hired labor used also is low in orange as compared to maize and rice (Table 12). The gross margin (net benefit) from existing orange tree is found negative until 6th year as the tree do not bear productive fruits. After the seventh year, the gross margin is positive which increases with increasing rate until the 14th year of its economic life. After the 15 years there is slight decrease in production of orange. The figure 3 shows the trend of net benefit from orange in different years of its economic life.

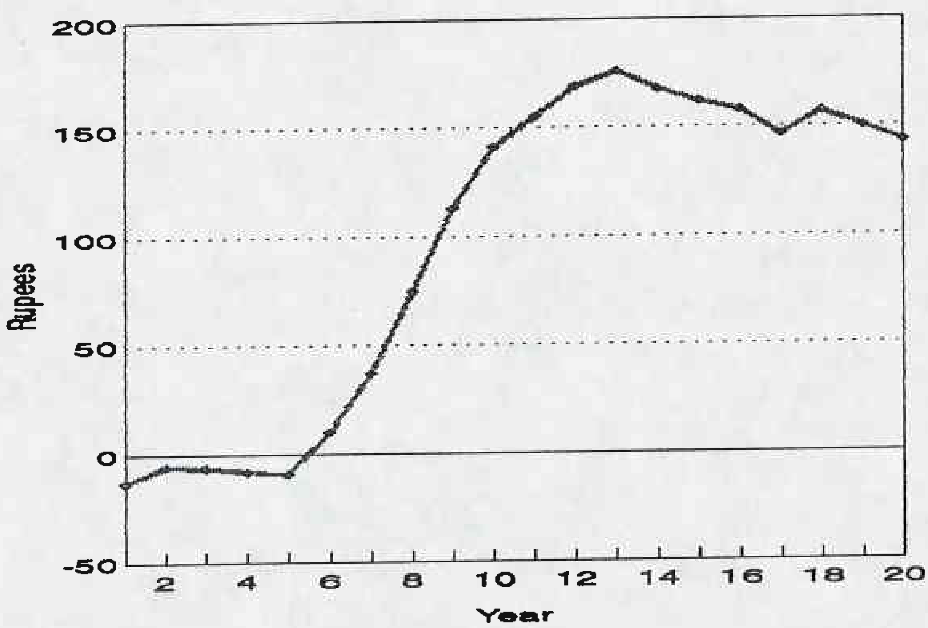

Figure 3 Net Benefit and Economic Life of Orange in Shankhu

Existing orange production is purely traditional type with low use of labor and purchased inputs. They have been practicing their own methods of planting and spacing. They plant local variety of orange in very high density (averages high as 640 trees per hectare) without any distinct recommended practice which grows taller and has longer gestation period. There is no use of labor unit for harvesting and marketing since fruit is sold to preharvest contractor long before harvest time of fruits. Even under low input traditional management and inefficient marketing systems, farmers are reaping high monetary benefits. In fact growing orange was found supplemental to crop and other production systems.

3.2.2.3 Marketing Environment

Marketing systems in the both sites are underdeveloped. Input market is only well developed for chemical fertilizers. Whereas output market is almost non existent except for citrus fruits in Sankhu site. Most of the farmers in the study area sell their produce particularly citrus fruits to preharvest contractors who offer low prices. Such lower share and return to the farmers result from the perishable nature of the fruit, low disposable amount of fruits, inadequate cold storage space, lack of transportation systems, and processing facilities.

3.2.3 Income and Employment Generation

3.2.3.1 Family Income

The total annual gross income per average household in the site II is very high as compared to the majority part of the hilly region, because of the income generated through the sales of citrus fruit. The sale of crops, fruit and livestock products are the immediate source of cash income for farm households in the study sites.

a. Farm Income:

Farm enterprise was the most important source of family income for all farm size groups in both Patlekhet and Sankhu site. However, Sankhu site had higher percentage of income from farm enterprises than Patlekhet. The higher farm income in Sankhu site, was due to integration of citrus fruits particularly orange production which played substantial contribution to farm income. It provides 80 , 69 , 68, 65 % of family income for the group I, II, III and IV farms respectively (Table 13).

b. Off-farm Income Opportunities

As return from existing farm activities has not been able to sustain their livelihood, farmers traditionally in those areas have adopted strategy to integrate off-farm activities with farm activities which have been the major part of the farming systems. The off-farm income contributes about 40 - 56% of total family income in Patlekhet as compared to 24.5% to 34.5% in Sankhu site depending upon farm groups (Table 12). Since the contribution of income from citrus in Sankhu was substantially higher, the relative share of off-farm in total family income remained low though the actual amount of earning from off-farm was found higher. The share of off-farm earning increased with farm size in both the study sites. This is because in the bigger farms, members of the farm households are better educated and earn their living more by services and trading. However, there was not distinct differences in off-farm earning among farm groups in both the study sites.

Table 13 Contribution of farm and off-farm income and their % share to total income by farm groups at Patlekhet and Sankhu VDCs'.

Farm group	Income sources			Income sources		
	Patlekhet			Sankhu		
	Farm	Off-farm	Total	Farm	Off-farm	Total
I	7469(46.7)	8523(53.3)	15992	16180(80.1)	4000 (24.7)	20180
II	11995(59.0)	8320(40.9)	20315	36409(69.7)	15769(30.2)	52178
III	17139(48.6)	18114(51.3)	35253	56208(68.3)	26072(31.7)	82280
IV	27413(43.9)	35000(56.0)	62413	91137(65.5)	48000(34.5)	139137
Mean	16004(49.5)	17489(50.5)	33499	49983(70.0)	23460(30.0)	73443

*The figure in parenthesis indicates % share of total income.

Though, off-farm work is prevalent to all size of farm operators, some type of off-farm work viz, wage laboring was more prevalent to marginal and small farmers. The remainder of off-farm income comes from such sources as trade, portering of milk and professional activities such as priests, witch doctors etc.

3.2.3.2 Employment

The farm activities i.e cultivation of annual field crops and livestock rearing and off-farm activities are the major source of employment in Patlekhet where as in Sankhu, citrus farming was the main source of employment as compared with other farm and off-farm activities. The off-farm activities commonly involved by farm households in both the study sites include wage labor (skilled nonfarm and farm labor), portering of goods and milk, cottage industries, services, trading and working as village priests. There was variation in the type of off-farm activity performed by farmers by ethnicity. The percentage of farmers involved in wage labor activity was higher in case of Tamang and Biswokarma. However, upper caste group especially, Brhamins are mostly worked within the village as priests for their off-farm earning.

3.3 Summary

There is much similarities in terms of biophysical and socio-conomic resources between two sites Patlekhet (Aruboat, Dandagaon, and Panditthok villages) and Sankhu which are situated in almost similar altitude ranging from 1200 to 1500 m above the mean sea level. Both the areas have sandy loam soils, more upland sloppy areas with similar altitude, topography and climatic settings. The cropping pattern is similar except citrus components in Sankhu site. The two major ethnic groups like Brahmin and Tamang are common inhabitant of both study sites. The labor and capital resource availability of farm households were found related to farm size. Both the sites are close to each other and only demarcated by a mountain range in between them.

However, Sankhu site is more prosperous due to integration of orange into their farm systems. Farm households derive substantial amount of income from orange production besides equally higher amount from off-farm earnings. The contribution of off-farm income to total family income was found higher in patlekhet than Sankhu site despite the higher absolute total off-farm income in Sankhu. The correlation analysis also revealed that there was strong positive relationships between family income and area under citrus production. Citrus production was found supplementary to crop and livestock production systems.

The return from upland crops as observed in Patlekhet site was not sufficient to sustain the livelihood of farm households particularly for group I and II farms. This necessitates the integration of alternative high income generating activities such as citrus into the existing systems.

CHAPTER IV

OPTIMUM FARM PLANS AND PRODUCTION

Planning farming systems with high value perennial tree crops in the mid hills region of Nepal is an effective way to determine a more profitable and efficient way of combining and allocating farmers' resources to improve long term farm income. In developing alternative multiperiod farm plans with fruit trees such as orange, the factors taken into consideration are farm resources limitation, and financial consideration faced by farm households, their priority for giving consumption requirements and need for enlarging their present farm business income levels.

In multiperiod planning the actual performance of the plan forms the basis for the next plan while at the same time future expectations are taken into account in all the planning work. In a complex subsistence farms such as in the hills of Nepal, multiperiod planning with mathematical programming model is useful in identifying alternative, optimal and substantially improved solutions for the improvement of the existing low productive systems which may be difficult from other simple straight forward approaches such as budgeting.

4.1 Assumptions in the Model

Long term planning with the use of multiperiod (dynamic) programming is a difficult undertaking. Lack of powerful microcomputers and increased possibility of computational difficulties of the multiperiod model with long term planning horizon such as twenty years becomes unmanageably large and complex. Therefore, besides the basic assumptions of linearity, additivity and divisibility of the linear programming (LP) model, the following assumptions were made in this multiperiod planning to reflect the existing farm production.

(i) It was assumed that relative product and factor prices would remain constant till the projected planning horizon since, there is really no way to adequately foresee technological changes and variation in the general economic climate.

(ii) Land availability for all sampled households was assumed homogenous resource in terms of topography, fertility, water supply and suitability for both annual and perennial crops (orange). In other words it assumes that area of the the mid hill region where rice and other annual crops are grown in hill terraces under rainfed or partially irrigated conditions are similar to the area in which orange is also cultivated successsfully.

(iii) The model assumes that farm households are fully employed in the off-farm activities as demanded during the off-season of the farming.

(iv) The activities of all annual crops are assumed to remain same, thus they have been duplicated from one period to next over the entire planning horizon.

(v) The model has been initialized to reflect the farmer's starting investment position. Therefore, it assumes zero saving in the first year of the investment in multiperiod planning. This is relevant to situation in the study areas as return from existing crop based systems do not provide enough income to save for the future investment.

(vi) Since, the growth rate of the population at Patlekhet site was found 1% per annum for the last few years (Shrama, 1993), this growth rate was assumed in the estimation of labor use and consumption requirements for each planning period over the entire planning horizon.

4.2 Data and Input-output Coefficients for Multiperiod Programming Model

In constructing matrices for the MLP model, two basic types of coefficients are required; input-output and the constraint coefficients. Data which have been used for calculating the coefficients were based on the data collected from the household survey of both the study sites in 1993. The supporting data were collected from available technical literatures from various concerned agencies and research stations.

Input price and output price paid for crops at farm gate is used for programming. Actual arable land owned by the farm households are used as the maximum land availability coefficient. Labor availability coefficient includes family labor and labor used on exchange basis which are treated as fixed resources in this model. Hired labor costs for peak farming season is calculated separately and included in the labor hiring activity column. Capital coefficient includes total variable costs spent on the various activities which is derived from previous year's farmers own saving and borrowed money from institutional sources when off-farm employment is not remunerative.

In the calculation of labor inputs for the orange production, the labor inputs for harvesting and marketing are not included as most of the sampled farm households in the existing situation sell the orange fruits to preharvest contractors before actual harvest who do the both harvesting and marketing of fruits. Nevertheless, marketing costs of orange was not found high as the farms were relatively close (about 5.0 km) to district markets and about 40 km far from central market, Kalimati, Kathmandu by motorable road. Farm households have provision to borrow credit from institutional sources at the normal rate of 16% interest for fruit trees, when own fund is not sufficient to meet the operating costs.

Off-farm wage rate used in this model is the average market wage rate of the study periods. For group I and II two farms, the average labor wage coefficient used is NRs. 50.00 in Patlekhet and 60.00 for Sankhu site. While for group III and IV farms wage rate of NRs. 100.00

has been used for programming as estimated from field survey where medium and large farms were earning higher amount / day because of their higher educational skills and involvement on more remunerative sideline activities such as services, skilled construction workers and trade etc.

Gross margin calculated in this study is obtained by deducting variable input costs (costs of fertilizers, seeds, planting materials, bullock labor costs, imputed costs of compost and farm yard manures etc.) from total revenue which is total output multiplied by its farm gate price. The total gross margin is calculated every year through a series of counting activities and balance rows. While calculating input-output coefficients for orange, it was found that gross margin becomes positive only after 6th year (c6 to c20).

The periods in the multiperiod programming are linked together through investment decisions. Interaction between periods is represented and accounted by the introduction of the inventory decision variables such as capital transfer activities. The objective function also provides a link between periods and typically the discounted sum of the total gross margin generated over the entire planning horizon is maximized. Every year, there will be a continuation of activities and key feature is that for every period there is a constraint.

For planning over time in multiperiod model, the input-output coefficients have been extrapolated from the present known situation with cross sectional data which is applied for any level of each activity during the planning horizon.

The consumption function in this study was determined separately to multiperiod programming model. The minimum consumption needs were estimated through survey based on actual needs and expenditure requirements for an adult for sustaining a decent life. The basic consumption expenditure is incorporated in the expenditure function through restriction procedures (Sriboonchitta, 1988) and assumed to increase linearly from present time to future based on the level of income.

The results depicted that the level of consumption has constant marginal propensity to consume (MPC) which is low as income increases, the consumption expenditure has been above minimum basic needs for farm households (Appendix table 1). After specifying minimum consumption requirements farm households do not spend more, probably because in the hills they have rarely an opportunity to spend more of their increased income.

4.3 Basic Optimum Plan

An optimum multiperiod planning for integrating citrus into existing hill farming systems has been done for two locations: Patlekhet and Sankhu site separately for a planning horizon of twenty years. The main objective of the plan was to maximize present value of future income (NPVI) subject to resources (land, peak season and off-season labor, capital) and consumption constraints. A simplified structure of multiperiod linear programming for citrus based hill farming systems is given in Table 14.

The details of land and labor (peak and off-season), consumption expenditure requirements and the input-output coefficients of orange for entire planning periods for Sankhu site are presented in Appendix Table 3, 4 and 6 respectively. The activities for annual based systems and resource requirements for Patlekhet site is given in Table 4, 8 ,9, 10 and Appendix Table 5. Two separate series of model runs using separate resources and input-output coefficents were made for each group of farm household for two locations to prepare basic optimum plan. Altogether four annual based for Patlekhet site and four citrus based basic multiperiod plans for Sankhu site were developed for different size of farms. Furthermore another four plans were developed and simulated for Patlekhet site with citrus to see the economic viability of citrus integration.

In the optimum farm plan for Sankhu site, the existing system with orange (citrus) is compared with systems without orange by eliminating the orange component from the optimum plan. However, for the Patlekhet, the optimum plan of existing crop based systems is compared with the simulated systems with orange by extrapolating the input-output coefficients from the Sankhu site.

Table 14. A STRUCTURE OF THE MULTI-PERIOD LINEAR PROGRAMMING MODEL FOR NEPALESE HILL FARMS

	OBJ:	YEAR 1 RC1	WT1	CN1	MT1	OR1	OF1	LH1	CB1	CA1	CT1	YEAR 2 RC2	WT2	CN2	MT2	OR2	OF2	LH2	CB2	CA2	CT2 . .
YEAR 1	PNV																				
	GM1	919	174	156	402	-1056	60	-60													
	LD1	1	1	1	1	1															
	LP1	9.75	2.3	3.15	1.25	11.56		-1													
	LW1	0.6	2.25	4.7	1.7	1.16	1														
	CR1					1056			-1												
	CE1									1											
	KB1	919	174	156	402	-1056	60	-60	1	-1	-1										
YEAR 2	GM2					-176			-0.16			919	174	156	402	-1056	60	-60			
	LD2					1						1	1	1	1	1					
	LP2					3.33						9.75	2.3	3.15	1.25	11.56		-1			
	LW2					1.16						0.6	2.25	4.7	1.7	1.16	1				
	CR2															1056			-1		
	CE2																			1	
	KB2					-176			-0.16		1	919	174	156	402	-1056	60	-60	1	-1	-1
	.					.			.							.			.		. .
	.					.			.							.			.		
YEAR 8	GM8					2384			-0.16							1184			-0.16		
	LD8					1										1					
	LP8					5.24										5.63					
	LW8					2.82										3.63					
	CR8															.					
	CE8																				
	KB8					2384			-0.16							1184			-0.16		1 . . .
	.					.										.					
	.					.										.					
YEAR 20	GM20					4688										4800					
	LD20					1										1					
	LP20					4.87										4.87					
	LW20					2.62										2.62					
	CR20																				
	CE20																				
	KB20					4688										4800					. . .

	OBJ:	YEAR 8 RC8	WT8	CN8	MT8	OR8	OF8	LH8	CB8	CA8	CT8 . . . . .
YEAR 8	GM8	919	174	156	402	-1056	60	-60			
	LD8	1	1	1	1	1					
	LP8	9.75	2.3	3.15	1.25	11.56		-1			
	LW8	0.6	2.25	4.7	1.7	1.16	1				
	CR8					1056			-1		
	CE8									1	
	KB8	919	174	156	402	-1056	60	-60	1	-1	-1
	.					.					. . . . .
	.					.					
YEAR 20	GM20					5632					
	LD20					1					
	LP20					5.6					
	LW20					3.02					
	CR20										
	CE20										
	KB20					5632					

ACTIVITIES
RC = Rice production activity
WT = Wheat production activity
CN = Corn production activity
MT = Mustard production activity
OR = Orange production activity
OF = Off-farm activity
LH = Labor hiring activity
CB = Credit borrowing activity
CA = Consumption activity
CT = Cash transfer activity

PNV = Present net value of income
OBJ = Objective function
GM = Gross margin
KB = Cash money balance
RHS = Right hand side
LD = Land constraint
LP = Labor availabiltiy in peak season
LW = Labor availabiltiy in off-season
CR = Credit row
CE = Consumption expenditure

Matrix size = 140* 220

(Contd... in the next page)

Interest rate (bank) = 0.16

Input-Output Coefficients (Unit)
Labor in Man /days
Gross margin and costs in Nepal rupees (NRs.)
Land in Ropani(0.05 ha.)

Table: 14 (contd...) A STRUCTURE OF THE MULTI-PERIOD LINEAR PROGRAMMING MODEL FOR NEPALESE HILL FARMS Gross Margin Accounting in different Years of the Planning period

				YEAR 20										YEAR 1	YEAR 2	.	.	.	YEAR 8	.	.	.	YEAR 20		
	OBJ:	.	.	RC20	YT20	CN20	MT20	OR20	OF20	LH20	CB20	CA20	CT20	GM1	GM2	.	.	.	GM8	.	.	.	GM20	STGN	RHS
	PNV																								
YEAR 1	GM1													1	0.862069	.	.	.	0.35383	.	.	.	0.059607	=	0
	LD1													-1										=	0
	LP1																							<	6.68
	LN1																							<	207
	CI1																							<	622
	CE1																							>	0
	KB1													-0.1122										>	12357
	GM2																							=	0
YEAR 2	LD2														-1									=	0
	LP2																							<	6.68
	LN2																							<	209
	CI2																							<	628
	CE2																							>	0
	KB2														-0.1122									>	12480
	.																							=	0
	.																							.	.
	GM8																							.	.
YEAR 8	LD8																		-1					=	0
	LP8																							<	6.68
	LN8																							<	223
	CI8																							<	666
	CB8																							>	0
	KB8																		-0.1122					>	13247
	.	.	.																					=	0
	.		.																					.	.
	GM20			919	174	156	402	-1056	60	-60														.	.
YEAR 20	LD20			1	1	1	1	1															-1	=	0
	LP20			9.75	2.3	3.15	1.25	11.56	.	-1														<	6.68
	LN20			9.6	2.25	4.7	1.7	1.16	1															<	243
	CI20							1056			-1													<	750
	CE20											1												>	0
	KB20			919	174	156	402	-1056	60	-60	1	-1	-1										-0.1122	>	14922
																								=	0

Discount rate = 0.16   Marginal Propensity to Consume (MPC) = 0.1122

Discounted by
r = 1/(1+i)*t
Where,
i = discount rate
t = year of relevant activity

Unit of Resource Supply

Labor in Man days
Cash in Nepal Rupees (NRs.)
Land in ropani (1 ropani = 0.05 ha.)

A. STUDY SITE I: PATLEKHET VDC

4.3.1 Existing and Optimum Plan for the Crop Based Farming Systems:

Annual crop (cereal) based systems is the predominant production systems in this study site. The optimal solutions with a combination of various farm enterprises and activities including off-farm by farm size are compared with the existing situation (Table 15).

Table 15 Farming systems in existing and optimal plan in Patlekhet

Farming Systems Activates	Unit	Existing systems				Optimum plan			
		I	II	III	IV	I	II	III	IV
Rice	area	2.07	7.50	7.11	17.0	6.17	17.2	26.61	41.08
Maize	,,	4.10	9.70	19.50	24.0	-	-	-	-
Off-farm		+	+	+	+	+	+	+	+

* The area is in ropani (1 ropani= 0.05 ha.)

The net present value of income is obtained by planning annual crop based systems with the provision of existing off-farm employment in group I, II, III, and IV, respectively. The optimal cropping pattern differs from the present mix of crops . In the existing situation all sized farms do grow major crops like rice, wheat, corn and mustard.

The optimal plan includes only one crop rice and off-farm activities represented in man days which remains same for all the planning periods. Off-farm earning in this site becomes an important activity in generating income for meeting minimum consumption requirements and for further investment.

Despite the low return from maize crop as compared with rice it is still grown by the farm households mainly for subsistence consumption both for human food and livestock feed. Currently, there is a physical constraint for growing rice. Though, growing rice is more profitable than other crops, it requires investment on water sources and terrace and bund construction which is more capital intensive. By the provision of more capital and increased household income farmers could switch from maize and other upland crops to growing rice wherever biophysically possible (below 1600 m from sea level) in order to meet their consumption and expenditure requirements. Therefore, though the optimal plan differs in the allocation of maize crop, there is a possibility to adopt rice crop through relaxation of capital constraint. The results of the programming model also show that net present value of income in this site increases with the farm size (Table 15).

The higher amount of increase in NPVI in larger farms (group III and IV) is not only because of large size of land owned by farm households but also higher amount of resources (labor and capital) commanded by them. Among farm resources, the land is the most scarce resource as indicated by high shadow prices during the beginning of the year (Table 16). That is addition of one unit area of land (0.33 ha.)

increases objective function value from NRs. 180 (US$ 1= NRs. 50.0) in farm group III to NRs. 500 in farm group IV. That is among different farm groups, group II has highest shadow prices. However, there was no difference in shadow prices among farm groups at the end of 20th year.

Table 16. Net present value of income (NPVI) and shadow prices of limited resources in the optimum plan in Patlekhet.

Particulars	Farm groups			
	Group I	II	III	IV
NPVI	126,577	185,083	367,295	492,041
Shadow price				
Ld1	420	500	180	237
Ld20	25	30	25	28

*Notes:

LD1 = Land in year 1, LD20 = Land in year 20

B. STUDY SITE II : SANKHU VDC

4.3.2 Existing and Optimum Plan for the Citrus Based Farming Systems

The farming systems in this study site is citrus (orange) based. The results of analysis with existing and optimum situation is presented in Table 17. The solution shows that there is difference in optimal mix of crops between existing and optimal plan. However, there was not so much variation in optimal plan among different groups of farmers. The major crops: rice, wheat, corn, mustard and orange present in the existing plans are reduced to two crops rice and orange in group I, and IV farms and only orange in group II and III i.e medium sized farm. This could be attributed to the difference in the resource endowments (labor, capital, land and variation in the purchased input used) of farm groups and their interaction with several factors.

Table 17. Farming systems in existing and optimal plan in Sankhu.

Farming systems activities	Unit	Existing systems				Optimum plan			
		I	II	III	IV	I	II	III	IV
Rice	area	2.07	6.82	10.25	17.00	0.37	-	-	1.70
Maize	,,	1.53	4.53	9.54	22.00	-	-	-	-
Orange	''	3.02	4.21	6.83	7.64	6.25	15.56	26.72	44.38
Off-farm		+	+	+	+	+	+	+	+

*The area is in ropani (1 ropnai = 0.05 ha.)

The farm group II and III will have only orange in the optimm plan. Rice in these groupds do not enter into the optimal despite it is profitable in growing in group I and to some extent to group IV.

The other crop activities particularly corn, wheat and mustard are not in the optimal solution though they are present in the existing situation since they are subsistence crops. With the increase of income farm households could fulfill their consumption requirements through market purchase of these crops . Besides they also have other important crop like rice for meeting consumption requirements. The programming solutions also show that orange and off-farm income enter in optimal plan in all the farm groups. Hence, orange is profitable to grow in all the situation. The optimum plan in terms of crop mixes remain almost unchanged until 20th year of planning periods. As similar to Patlekhet site the net present value of income increases with farm size. The increase of NPVI is higher in larger farms because of higher amount of resources owned by them (Table 18).

Table 18. Net Present Value of Income (NPVI), and Shadow prices of limited farm resources in the Optimum plan in Sankhu

Particulars	Unit	Farm groups			
		I	II	III	IV
NPVI	NRs.	161,053	223,774	382,191	493,410
Shadow price					
Land1	NRs.	414.00	509.00	213.00	522.85
Land20	,,	26.49	30.00	30.00	32.10

Among different farm groups, addition of one unit of land resource increase objective function value by NRs. 522 for group IV as indicated by highest shadow prices (Table 18). However, at the end of planning period shadow prices remain same for all farm groups. The results also show that shadow price decreases with the increase in planning period.

4.3.3 Comparison between existing two Production Systems: With and Without Orange:

Two different systems of farming are evaluated here for their impacts on cropping patterns, net present value of income (NPVI) and employment. (a) Systems with existing production with mandarin orange and (b) Systems without mandarin orange production. In this case investment in mandarin orange has been evaluated within the context of whole farming systems.

The solution to the multiperiod programming analysis over a planning horizon of 20 years would indicate whether investment in mandarin orange is profitable under the estimated costs and returns, that is whether any of the alternative production systems enter the optimal farm plan. The programming analysis of following table reveals the clear differences between the level of profitability between the annual based systems and the systems with mandarin orange production. The results show that the systems with orange, gives higher family income(NPVI), than the systems without orange.

It can be concluded from the programming solutions that elimination of orange enterprise from existing systems can bring reduction of net present value of income by 12 to 17 % depending upon farm size as compared to systems with orange (Table 19). This enterprize also provided more employment to farm households during slack period besides their contribution to family nutrition and intangible environmental benefits.

Table 19. Comparative analysis of net present value of income (NPVI) from two systems: systems with and without orange in Sankhu.

Farm Group	Systems with orange NPVI (NRs.)(a)	Systems without orange (b) NPVI(NRs.)	% Difference (b/a-1)*100
I	161,053	132,396	-17.79
II	223,774	194,318	-13.16
III	382,191	332,667	-12.95
IV	493,410	406,378	-17.63

Source: Computed from field survey, 1993

Furthermore, due to continuous soil erosion and fertility decline in the mid-hills of Nepal, it can be assumed that there will be reduction in the yield of annual crops if they are continued to grow without any conservation measures. Besides, production of rice in the fragile hill terraces is also not desirable from the environmental point of view because of weight of irrigation water on the terraces which cause not only damage to the terrace and other physical structures but also land slides and destruction of the whole areas which can be seen in many parts of the mid hills during rainy season. Therfore, substitution of annual crops including rice is desirable by fruit tree such as orange both economically and environmentally.

4.3.4 Integration of Citrus into existing Systems in Patlekhet

The Survey of the sampled households in study site I (Patlekhet) shows that a majority of the farm households have little or no margins over and above their basic subsistence requirements. Under such circumstances, there is a need to integrate high pay-off farm activities such as orange into existing production systems without deteriorating the long term productivity of the land.

The results from basic optimal plan in Sankhu (study site II) also indicated that integration of this fruit in the existing systems is economically viable and it can have major socio-economic benefits to small farmers by increasing net present value of income by more than 14% over a planning horizon of 20 years. Besides this, orange being perennial fruit tree, gives several benefits to rural farm households such as better nutrition, more cash income and employment of family labor during slack season, utilization of marginal, erosion prone sloppy land in addition to soil conservation and ecosystem stability (Nair, 1984, Kainee, 1993a).

This economic and other multipurpose benefits of the orange tree necessitates the integration of orange as similar to Sankhu site in other areas of mid-hill region, where poverty and resource degradation have put miserable situation to many hill farms. Furthermore, the rationale behind the study and integration of citrus in study site I, through programming analysis of farming systems is that there is a possibility of growing citrus fruit in the existing crop based systems due to its high economic viability, technical feasibility and socio-cultural acceptability of the local people. The adoption of citrus fruits by some innovative farmers in Dandagaon area and growing of one or two trees by every household in the homesteads in study site I, substantiate the technical feasibility and acceptability of the fruits at the local level.

Therefore, the multiperiod programming analysis of existing crop based systems with citrus integration in the different resource context of Patlekhet site is done by extrapolating the data and input-output coefficients of orange from study site II, using mathematical programming technique. Where as the coefficients for crop activities and resources is used from the existing cross sectional data from field survey. The main objective of this analysis is to observe the changes in NPV of income and cropping pattern and derive policy implication for introducing citrus in a larger scale to achieve sustainabiltiy of the hill agricultural systems.

The existing annual field crop based production systems of Patlekhet site is compared with the simulated results of the systems that integrate citrus (Table 20). In the basic optimum plan of the simulated systems both orange and rice enter into the optimum plan.
As similar to Sankhu site, the upland crops like maize, wheat and mustard also do not enter into the optimal plan in this site under simulated condition. The optimum plan in terms of crop mixes remain almost same through the years until 20th year.

Table 20. Farming systems in existing and optimal plan (simulated) in Patlekhet.

Cropping Systems Activates	Unit	Existing systems				Optimum plan			
		I	II	III	IV	I	II	III	IV
Rice	area	2.07	7.50	7.11	17.08	-	2.07	0.40	-
Maize	,,	4.10	9.7	19.50	24.00	-	-	-	-
Orange	''	-	-	-	-	6.17	15.12	26.21	41.08
Off-farm		+	+	+	+	+	+	+	+

Table 21. Net present value of income (NPVI), and shadow prices of limited farm resources in the Optimum plan (simulated) at Patlekhet

NPVI and Shadow prices	Unit	Farm groups			
		I	II	III	IV
NPVI	NRs.	139,887	215,803	425,240	575,583
Shadow price					
Land1	NRs.	420.00	887.06	430.00	237.5
Land20	,,	25.20	30.00	18.00	21.5

However, by integrating citrus the shadow prices of land increased particularly in group II and III farms (Table 21) as compared with existing annual based systems (Table 16). The higher shadow prices of land in group II and III farms indicate the higher marginal productivity of the land with the inclusion of citrus into the existing systems.

However, as similar to Sankhu site there was no difference of shadow prices at the end of planning horizon among different farm groups.

4.3.5 Comparison between two Systmes: Without (existing) and with orange (Simulated) condition in Patlekhet Site

With the integration of citrus into existing crop based systems at Patlekhet site, the results of multiperiod programming model showed that there is more than 10 % net increase of net present value of income in all farm size groups over a planning horizon of 20 years (Table 22). The increment in NPVI was higher in the farm group II and III as compared with group I and IV.

Table 22. Potential contribution of citrus integration (simulated) into existing systems

Farm groups	Existing systems with field crops (annual crops) NPVI(NRs.)(a)	Integrated systems with orange tree NPVI(NRs.)(b)	% Difference (b/a-1)*100
I	126,577	139,887	10.5
II	185,083	215,803	16.5
III	367,295	425,240	15.7
IV	492,041	575,583	11.7
Mean	292,749	339,128	15.8

Source: Computed from field survey, 1993

4.4 Summary

The results obtained from the application of multiperiod programming models indicate that the incremental benefits from the orange fruit is fairly high such that the elimination of the orange enterprize from the present farming activities at Sankhu site would cause considerable loss (12-17% depending on farm groups) in terms of net present value of family income. Similarly, by simulating the existing crop based systems with orange in Patlekhet site, it gave 10-16% higher return (NPVI) over the existing crop based systems in different farm size groups.

The results also show that orange and rice are competitive crops in the range of current price ratios and production technology. However, corn, wheat and mustard are not profitable in the current price ratio, resource conditions and production technology as they do not enter in the optimum plan in all farm size groups. From above programming solution, it is obvious that citrus based system is more profitable land use approach in the hills as compared to annual based systems.

The results of this study both from the existing and simulated situation therefore, would confirm that by integrating high pay-off fruit trees like orange can bring substantial improvement in income of farm households in the hill region where farm size is very small, and barely enough to sustain farm family from annual crops. The application of the finding however, should be based on results of the sensitivity analysis.

CHAPTER V

POLICY ANALYSIS

An important and correct general strategy for sensitivity / policy analysis is the (a) "with minus without approach" and (b) changing the economic and technological constraints (Davis, 1992). In policy analysis farming system is evaluated with the discrete sets of additional constraints and so as proposed for a new policy and comparing the results to these found under current policy for the system "without" the new constraints. The basic optimum plan or current management practice is the best reference point to measure the effect of policy changes.

The purpose of the sensitivity analyses in this study is to determine the alternative plans when economic and policy environment changes, besides testing the validity and stability of the purposed model. It is also done here to take account of risk into the farm plan as it is fairly a rough and ready means of measuring risk (Timothy, 1991). Policy analysis in this study seems especially appropraite since farmers with different socioeconomic classes and resources, (such as in the hill of Nepal), have different goals, resource availabiltiy and resource constraints.

Mathematical programming facilitates decision making process by showing the consequences of series of policy goals encompassing the whole activities of the farm systems. In view of the household's goals to maximize net present value of income (NPV) subject to various constraints imposed by scarce resources, complex inter-relationship among crops, and household labor and other interdependencies among activities in the farm systems of Nepal hills, mathematical programming appears to be a much superior technique to examine effects of many alternative available policy options (Tulachan, 1989).

The sensitivity analyses in this study has been done for Sankhu site which covers various changes in output prices, wage rate, labor demand for off-farm activities, discount rate, and different scenarios of farming systems and policy variables.

5.1. Scenario I: Changes in Prices

5.1.1. Changing Output Price of Orange

Changing the output price especially, the price of orahge fruits play an important role in the optimum plan and the profitability of the enterprise. The results of the sensitivity analysis under various price assumptions showed the changes in net present value of income and on land use by changing price from base run to NRs. 5 and 10.0 (Table 23 and 24). When price is decreased to NRs. 5.0 (by 28%) the optimal solution will only include rice in all farm groups. However, increase price from Nrs. 7.0 to 10.0 (by 42%) will substitute rice completely by orange in all three farm groups except group I (marginal farm). The marginal farms will have still same amount of land devoted for rice production as in basic plan which indicates that they are not responsive to increased price of orange until this range probably because of the profitability of rice under its given resource endowments and technology. This also depicts the preference criteria of margianl farms for their subsistence requirements of rice.

Table 23. Effect of change of orange price on NPVI for different farm group in Sankhu (Base price of orange = NRs 7/kg)

Farm group	NPVI in different price range NRs./kg of fruits		
	7.0	5.0	10.0
I	161,053	158,029	194,818
II	223,774	195,707	241,486
III	382,191	332,630	407,293
IV	493,410	406,625	539,183

The switching over of rice land to orange by medium and large farms in response to higher orange price could be possible in some areas of mid hill where rice is grown in hill terraces under rainfed or partially irrigated conditions. It is reported that farmers in some of the road side areas of mid hills (Lamjung and Gorkha districts) where rice is grown on monsoon rains, is being converted to orange production because of its higer profitabiltiy.

Table 24. Effect of orange price change on optimal crop plan in various farms in Sankhu (Base price of orange = NRs 7/kg)

Farm groups	Various price changes in orange (in Nepal rupees)					
	7.0		5.0		10.0	
	rice	orange	rice	orange	rice	orange
I	0.37	6.25	0.37	6.25	0.37	6.25
II	0.00	15.56	15.56	0.00	0.00	15.56
III	0.00	26.72	26.72	0.00	0.00	26.00
IV	1.70	44.38	46.01	0.00	0.00	46.09

Note : Crop area in ropani(1 ropani area = 0.05 ha.)

5.1.2 Sensitivity of orange production to yield and price decline after middle of the planning horizon

a. Price decline by 15% after middle of the planning horizon

This analysis has been done here to take into account of market risk in the future When majority of the farmers integrate citrus into their existing systems. In this assumed situation, in the near future the market most likely would be flooded and price of orange would decrease substantially if proper market outlet is not developed. Therefore, sensitivity analysis has been done here by decreasing the price coefficent of orange from NRs 7.0 to 6.0 (about by 15%) after 10 years of planning period in order to take into account of market risk of growing orange (Table 25).

Table 25 Effect of 15% price decline on NPVI after middle of planning horizon

Farm groups	NPVI in decreased (15%) price of orange	
	NRs. 7.0	15% low price
I	161,053	155,395
II	223,774	195,707
III	382,191	333,946
IV	493,410	443,409

* Two price regime that is base price (NRs. 7.0 /kg) is used in the first 10 years and NRs. 6.0 /kg of fruit (15% lower) is used from the 11th year to 20th year of the planning horizon .

Table 26. Effect of 15% price decline on optimum crop plan after middle of planning horizon (10 years)

Farm groups	Optimal crop plan in 15% price decline			
	NRs. 7.0/kg		15% lower price	
	Rice	Orange	Rice	Orange
I	6.25	0.37	6.62	0.00
II	0.00	15.56	15.56	0.00
III	0.00	26.72	22.96	3.75
IV	1.70	44.38	7.91	38.17

The Table 26 reveals that even under adverse situation of price decrease by 15%, orange comes in optimal plan along with rice and off-farm activities in group III and IV (medium and large farmers). This finding is also supported by the feasibility studies conducted for citrus farming project by APROSC (1989) where citrus is economically viable even under adverse situation of price decline 10% and cost increase by 10%. However, orange does not come in the optimal plan for farm group I and II though net present value of income is high since it will not be so profitable to grow orange as compared with rice. This could because of the interaction of several factors including relatively more labor resource endowments of marginal farms and higher gross margin from the production of rice. This finding reveals that smaller farm sizes are more sensitive to price change of orange compared with large farmers (Table 26).

b. Yield decline by 15% after middle of planning horizon

The objective of this analysis is to account the yield risk of declining production after tree reaches maturity. It is often common that farmers in the many rural hill areas suffer from declinng yield of orange tree because of diseases, pest and climatic variability (e.g. hail storms). In order to account this factor into analysis lower yield coefficients of orange is employed.

Table 27 Effect of yield decline on NPVI after middle of planning horizon

Farm groups	NPVI under declining orange yield situation	
	Base run	Decline Yield
I	161,053	155,395
II	223,774	195,707
III	382,191	333,946
IV	493,410	411,688

The programming analysis (Table 27) also show that orange is profitable for group III and IV (medium and large farms) even under the projected lower yield (15%) situation after middle of the planning horizon.

Table 28 Effect of yield decline on optimal crop plan after middle of planning horizon

Farm groups	Optimal plan under declining orange yield situation			
	Base run		Decline Yield	
	Rice	Orange	Rice	Orange
I	6.25	0.37	6.62	0.00
II	0.00	15.56	15.56	0.00
III	0.00	26.72	22.96	3.75
IV	1.70	44.38	16.60	29.48

The programming results presented in Table 28 revealed that the crop mix in the optimal plans are orange and rice in the III and IV groups (medium and large farms) and only rice in group I and II (marginal and small farms) which is similar to projected lower price conditions. This findings also indidcate that smaller farms will be affected by yield decline in the long period where as medium and large farms are virtually unaffected.

5.2 Scenario II: Changes in demand for Off-farm labor

From household survey results of the study site, it has been found that about one or two adult members from marginal and small farm households in the study sites are employed in off-farm activities for a period ranging from two to eight months. In order to test the sensitivity of the basic optimum plan under various labor demand conditions, assumption has been made in the model by reducing off-farm labor constraint coefficients to 75%, 50%, and 30% of the total actual supply. The results showed drastic reduction in NPVI (Table 29).

Table 29. Effect on NPVI due to variation in the demand for off-farm work (base demand = 100%) in Sankhu

Farm groups	Variation in the demand of Off-farm work (man days)			
	100%	75%	50%	30%
I	161,053	102,538	89,009	51,506
II	223,774	184,812	142,878	107,077
III	382,191	273,993	214,709	165,367
IV	493,410	390,025	313,190	250,085

When labor demand is 50% and 30% of the total supply, the optimal plan includes relatively more area under rice as orange production becomes not so profitable. This could be so because of lack of enough fund to invest on orange due to reduction of income from off-farm activities. When labor demand is only 25% of the total supply, the solution becomes infeasible as the family income will not be enough to meet basic consumption requirements and investment on fruit tree. Therefore, in this situation farm households need to borrow credit for the investment on orange .

Table 30. Effect on optimal crop plan due to changes of demand for off-farm work (base demand = 100%) in sankhu

Farm group	Optimal crop plan in various labor demand in off-farm work (man days)							
	100%		75%		50%		30%	
	rice	orange	rice	orange	rice	orange	rice	orange
I	0.37	6.25	0.37	6.25	3.05	3.57	6.00	0.61
II	0.00	15.56	3.68	11.87	3.16	12.39	8.53	7.02
III	0.00	26.72	2.59	24.12	9.70	17.00	15.38	11.34
IV	1.70	44.38	14.80	31.28	15.22	30.86	21.34	24.74

The results of this analysis indicates that there is positive relationship between off-farm work and investment on orange production as area under orange decreases with less demand of off-farm work (Table 30). This is because decrease demand for labor results reduction in off-farm income, consequently low net present value of income which in turn leads to switch over to rice as there will be low investment in orange production. Therefore, area under annual crop (rice) increases as demand for off-farm work decreases indicating negative relationship between rice production and off-farm employment (Table 30).

If off-farm employment opportunities are completely withdrawn, the farm households in both the study sites would have no sufficient family income to meet basic consumption requirements and investment for orange fruits. Therefore, the basic plan becomes infeasible for all farm sized groups. This indicates that off-farm income is indispensable for not only long term investment in orange trees but also sustaining the basic livelihood of resource poor hill farmers. This result is consistent with result of Yaha, *et al.* (1992) who found that off-farm income is important in expanding permanent farming systems in the Highland of Chiangmai province, Northern Thaailand.

5.3 Scenario III: Effect of capital (credit) borrowing

Though programming model includes provision for borrowing credit from institutional sources for investment on citrus when existing capital is exhausted the results revealed that no credit was found borrowed in all farm groups untill the farm households are partially employed (> 25% demand) in off-farm during off-season. However, when exisitng off-farm work days are reduced to less than 25% of the original base demand, then without credit borrowing investment on orange is not possible. Therefore citrus growing households would not be self-financed and credit borrowing is required if farm households spend less than 25% of their available work days in off-season as revealed by programming results.

This results is also relevant to actual situation of the field as farm households in Sankhu site have already utilized about 52% of their available work days during offseason in off-farm activities and found earning sufficient income from off-farm employment (brick making, trekking, construction works and other various side line activities including trade and services) to finance for citrus production. Therefore, in majority cases farmers hesitate to borrow credit from institutional sources due to high transaction costs and also the less information about actual borrowing procedures. In the existing situation only few households who do not have remunerative employment have used borrowed money from institutional sources in citrus production. The Marginal value product of credit was found high under less off-farm employment situation, indicating crucial role of credit if off-farm employment is not remunerative and opportunity costs of labor is very low or zero.

5.4 Scenario IV: Changes in off-farm Wage rates

The basic model for off-farm wage work includes valuation of family labor during off-season equivalent to usual rate for hired male labor during the peak farming season. Here the implicit assumption is that the opportunity cost of family labor equals the market wage rate and does not consider the differences in sexes and skills. However, such assumption is not always valid because the opportunity costs of family labor varies over the season and years due to seasonality in its demand.

Therefore, in this case parametric programming analysis has been carried out by changing off-farm wage rate equal to opportunity cost of family labor during both slack and peak farming seasons. It is assumed that farmers would earn 75% to 50% of the going wage rate during slack season and 125% to 166% of the going wage rate during very busy time of the farming.

Table 31. Effect of off-farm labor wage rates on NPVI for different farm groups (base wage rate (Wo) = NRs. 60.0)

Farm group	Changes in off-farm wage rate (NRs.)				
	Wo	W1	W2	W3	W4
	60.0	45.00	30.00	75.00	100.00
I	161053	127915	106048	189025	245075
II	223774	166521	130964	234272	289612

The rest two groups of farms (group III and IV) were not used for the analysis as for them, off-farm work especially wage laboring was not prevalent. The results from the Table 31 and 32, show that there is a change in the optimal plan showing that changing the off-farm wage rate will substantially change the optimal plan and net present value of income. The optimal area under orange increases with the farm size and increasing the wage rate. The results also depict that remunerative off-farm work will lead to inclusion of more area under orange as observed from Table 32 because off-farm income provides ready cash for the investment on orange production.

Table 32. Effect of off-farm labor wage rates on optimal crop plan in Sankhu (base wage rate = NRs. 60.0)

Farm group	Optimal area allocation under different crops									
	60.0		45.0		30.0		75.0		100.0	
	rice	orange	rice	orange	rice	orange	rice	orange	rice	orange
I	0.37	6.25	0.37	6.25	1.18	5.43	0.00	6.62	0.00	6.62
II	0.00	15.56	3.04	12.51	7.13	8.425	0.00	15.56	0.00	15.56

5.5 Scenario V: Changes on discount rate

Discount rate which indicates cost of capital is an important factor that determines the profitability of the farm systems. In this study, two discount rate 12% (interest rate for fixed deposits) and 20% (interest rate for consumption loans) have been used to see the changes on NPVI and optimal crop plan. Both use of lower and higher discount rate have significant effect on NPVI (Table 33). The results also show that higher discount rate substitutes the orange by rice completely in all the farm groups. Similarly, lower discount rate of 12% changes the optimal crop mixes but except in group I farm (Table 34).

Table 33. Effect of changes on discount rate on NPVI in different farm types in Sankhu (base discount rate = 16%)

Farm Group	Variation in discount rate		
	16%	12%	20%
I	161,053	206,593	136,894
II	223,774	269,411	164,143
III	382,191	453,609	278,693
IV	493,410	583,982	340,281

In this case group I (marginal farms) will have both rice and orange production in the optimum plan as similar to basic plan which indicates that they are not responsive to lower discount rate.
If government provides a subsidy in the credit disbursement by reducing present interest rate from 16 to 12%, then farm groups II, III and IV will

switch over from rice to orange production as it is more profitable for them. However, the optimal plan of group I farm will have no changes in cropping plan except increase in net present value of income (Table 34) which depicts that they are not responsive to lower discount rate.

Table 34. Effect of changes on discount rate on optimal crop plan in Sankhu (base discount rate = 16%)

Farm group	Optimal area allocation under different crops					
	16%		12%		20%	
	rice	orange	rice	orange	rice	orange
I	0.37	6.25	0.37	6.25	6.62	0.00
II	0.00	15.56	0.00	15.56	15.56	0.00
III	0.00	26.72	0.00	26.72	26.72	0.00
IV	1.70	44.38	0.00	46.00	46.01	0.00

This is probably because of the no significant increase on the saving of return to invest on orange for its future even under low discount rate and in addition to this, rice becomes relatively profitable for this group. In the reality also rice land for marginal farms is essential for meeting consumption requirements. Therefore strong institutional credit support services are required to attract group I or marginal farms in the investment on citrus fruits.

5.6 Scenario VI: Fully Upland Situation

The analysis and simulation of farm plan under the assumption of fully upland situation seems quite meaningful as many of the farm households in the hills of Nepal have only rainfed upland for agricultural production and many of the small farm household rarely own paddy land (khet) for rice cultivation. This is also observed in the present study sites where 15% of sampled households did not have low land. Integration of perennial high value crops like citrus in the upland situation should be a good alternative to increase long term farm income as return from existing maize based systems is declining.

Unlike the basic optimum plan the results showed that orange is the only upland crop that comes into the optimal solution (Table 35). However, in this situation growing mustard is cost effective as it does not bring any reduction in the objective function value. But there is slight reduction in the NPVI (5%) as compared with base run due to omission of rice production activities in the model.

Table 35. NPVI and optimal crop plan in upland situation in farm group I in Sankhu

NPVI & Optimal Crop	Unit	Orange with upland crops & Rice (Base run)	Orange with upland crops & no Rice (A)	Systems with only annual upland crops (B)	% Difference (A/B)*100
NPVI	(NRs.)	161053	152048	132396	14.84
Optimal crop	area	6.62	6.62	6.62	0.0

Orange	ropani	6.25	6.62	0.0	0.0
Rice	,,	0.37	-		
Mustard	,,	-	-	6.62	0.0

Despite this, the system with upland crops and citrus is still found 14% more profitable as compared to the systems with only upland crops. No much changes on optimum plan and return were observed by omitting rice in the optimum plan.

5.7 Scenario VII: Effect of improved technology and marketing

The sensitivity analysis was also done by comparing existing situation versus improved situation with better technology, and improved marketing practices. Input- output coefficients for improved situation of citrus integration is prepared by using today's most advanced technologies adopted in research stations, and commercial farms under the assumption that over time a sizeable number of farmers will tend to adopt this advanced technology.

a. Effect of improved technology (planting material) and cultural management of citrus

It is widely believed that improved technology of fruit trees such as improved genotype plays important role in improving farm productivity and income. However, the multiperiod programming analysis of the improved mandarin orange in Sankhu site showed that there was not much impact of improved genotype on long term family income as compared with traditional genotypes under present production systems, resource availability and constraints of the farm households (Table 36).

Table 36. Effect of improved technology and management practices of citrus on NPVI and Optimal plan for farm group I in Sankhu.

NPVI & Optimal plan	Existing situation (NRs)	Improved situation (NRs)	Difference %
NPVI	161,053	165,766	3
Optimal plan			
Rice	0.37	0.37	0
Orange	6.25	6.25	0

Despite the higher potentiality of improved mandarin fruit trees in terms of yield and better quality fruits this minimal effect of technology was because of the demand for relatively higher amount of resources particularly that of purchased inputs and hired labor, in addition to shorter economic life of improved mandarin orange. This indiccates that when marginal productivity of labor is high that is if off-farm employment is remunerative the introduction of new technology in citrus will have less impact on improving income.

b. Effect of improved marketing practices in citrus

In order to know the impact of direct marketing of fruits at near by markets input-output coefficients for direct marketing practices has been used for programming analysis. Farmers were found to recieve NRs.

7/kg of fruit in the existing situation as compared with the direct sale at market in NRs. 10 /kg of fruits.In this analysis the transportation and harvesting costs are added in the total costs where as most of the other things remained other same.

Table 37. Impact of Improved marketing practice of citrus on family income (NPVI) and Optimal Plan in group I farm in Sankhu

NPVI	Return from different Marketing practices in citrus		
	Existing* NRs	Improved** NRs	Difference %
NPVI	161,053	181,040	15.2
Optimal plan			
Rice	0.37	0.37	0.0
Orange	6.25	6.25	0.0

* Existing = marketing fruits to preharvest contractor at farm gate.
** Improved = marketing by farmers themselves in the near by markets.

The programming results which are presented in Table 37 indicated that, there is a greater impact of improved marketing practice in NPV of income than that of improved technology (improved orange genotype) in Sankhu site . This is because farmers receive higher price of orange fruit (>30%) just through slight changes in marketing practice that is from contract selling before harvest to direct marketing after harvest which has been already practiced by some of the resource rich farmers.

5.8 Scenario VIII: Intercropping food crops at juvenile stage of orange tree

Survey results show that small holders because of their very small size of farm prefer to intercrop food crops during juvenile stage of orange to fulfill their basic consumption requirements. Therefore, MLP analysis has been done in the basic optimum plan particularly for group I (marginal farmers) in order to see the effect on the net present value of income and thereby profitability of the systems with and without intercroping of food crops between trees. The input- output coefficients of commonly intercropped food crops: maize during summer and mustard in the winter are used in the programming model for planning.

Table 38. Changes in optimal plan and Income (NPVI) by intercropping crops with orange trees in Sankhu (group I).

NPVI & Optimal plan	Systems W/o * Intercropped orange	Systems With Intercropped orange	Difference
NPVI	161972	165572	2.9(%)
Optimal plan			
Rice	0.37	3.27	2.9
Orange	6.25	3.35	-2.9

W/o * = Without

In calculating coefficients for intercropped situation, 90% area was occupied by the annual crops in the year I. In year II and III 80 and 70% of the area were devoted for intercrops respectively. For the year 4th and 5th 60 and 50% area were used for this purpose. The resources required and output obtained were estimated based on the area in the intercropping. There is slight increment in net present value of income by 2.9 % when food crops (maize and mustard) are intercropped during juvenile stage of mandarin orange tree (Table 38). However, there is a decrease in the area under orange in optimal plan by intercropping.

Despite decrease of the area under orange and slight increase in NPVI, intercropping at juvenile stage is beneficial for small farm households as it provides not only food security but also compensate the foregone production from land occupied by citrus. Such intercropping also provides income for investment on orange fruits for resource poor farmers.

5.9 Summary

Sensitivity analysis of the existing citrus based farming systems of Sankhu site indicates that off-farm employment has important role for the economic viability of hill farming systems and without off-farm employment it is not only difficult for meeting household consumption requirements but also in the investment on citrus production. Off-farm work by farm family members always enter the optimal solution for every farm group in all the planning period until 20th year. It is also found that in the future when wage rate increases, orange becomes more profitable so farmers would switch into orange from rice as they would earn more income from off-farm. The results also point out that even under the well established orange production systems there is still room for family members to engage in off-farm work during slack period of the farming.

In addition to off-farm employment and wage rate, output price of orange, discount rate used and improved marketing practice also had some impact on improving long term farm income and investment on orange production. Increased orange price from NRs. 7 to 10 /kg (by 42%) and decreasing discount rate from 16 to 12% make farm groups completely to switch over to orange production while group I farms still have rice land in their optimum plan including orange and off-farm works. Price and yield decline of orange after middle of planning horizon will make marginal and small farm households to substitute orange to rice completely while members of the large and medium farm groups are unaffected by this type of adverse situation.

The role of improved technology of citrus and intercropping at Juvenile stage had minimal impact on long term income despite the fact that intercropping might improve food security and reduce the risk of investment in orange production. However, the analysis showed that improved marketing had greater impact since farm households can improve their income substantially due to higher price received from direct sale of fruits.

CHAPTER VI

CONSTRAINTS AND BENEFITS TO CITRUS INTEGRATION

This study also aimed to assess and integrate the qualitative information as evaluated by farm households into quantitative evaluation framework in order to understand the economic viability and environmental (soil conservation) merits of the enterprises. The finding shows that incorporating orange as a system component may bring about several socioeconomic advantages such as increased income and environmental benefits (soil conservation) in comparison with annual crops.

Despite the potential economic benefits of orange, however, until now, its integration has not been very successful in Nepal's mid hill region. A number of socioeconomic and agronomic constraints may prevent farm households to adopt, integrate and expand orange into the present farm systems.

6.1 Constraints:

Descriptive assessments have been used to analyze the constraints to citrus integration by using farmers perception and views. The following information was obtained from the analysis of sampled farmers (Table 39).

Table 39. Farmers' Responses of the constraints to citrus integration into the existing Systems:

No.of Respondents	Percentage	Responses
20	16.25	Lack of land and small sized holding
31	25.25	Lack of knowledge and no technical information and incentives
29	23.25	No markets and infrastructures(Roads).
21	16.75	Lack of resources and funds (Capital)
5	4.50	Water constraints
10	8.50	Lack of family member(s) to manage and care trees
7	5.50	Lack of security of fruits from stray animals and local children
N=123	Total% 100	

Responses of sampled households of both study sites i.e Patlekhet (Dandagaon, Aruboat, Panditthok, and Baniachhap villages) and Sankhu VDC's have been collected in order to trace out the major constraints that make the farm households not to adopt, integrate and expand the production of citrus in the existing traditional crop based systems. Tabular analysis of the above information based on farm sizes shows the following results (Table 40).

Table 40 Percentage Scoring of the major constraints to citrus integration by farm size.

Farm Groups	Land	Labor	Capital	Market	Technology	Water	Output Security	Total
I	50	5	23	6	9	2	5	100
II	17	8	35	15	15	6	4	100
III	0	9	10	34	36	4	6	100
IV	0	10	2	38	40	3	7	100
Total	67	32	70	93	96	15	22	400
Percent(%)	17.0	8.5	17.5	23.2	24	4.0	5.5	100

From the above results it is inferred that different type of constraints are impeding in citrus integration for different farm size. Table 40 reveals that group I or marginal farmers (50%), responded that small size of land which was mostly devoted for grain crops was the major constraint in the integration followed by fund or capital unavailability. Where as group II reported lack of capital (35%) followed by land size (20%) as the major problem. The III or medium farmers reported technological information and market are the major constraints. The group IV (large or resource rich) farmers reported the lack of market (38%) followed by technological information(36%) as the major constraints to its adoption and integration. Lack of labor force to plant, care and manage, water constraints and also damage from stray animals and theft from local children are also reported to be constraints to some of the farmers.

Over all, as shown in figure 4, the main constraints observed were lack of technological information, poor marketing systems, lack of capital resources and land. However, smallholders (group I and II) may not foresee that technology will become a problem since the land is the serious constraints which obstructs them to move further for the long term investment in citrus fruit.

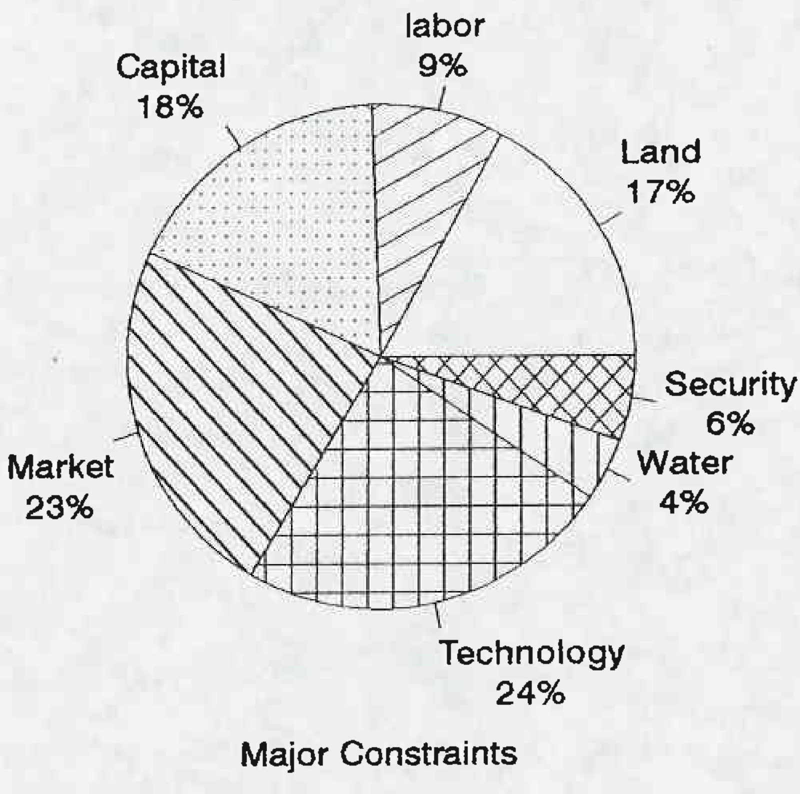

Figure 4. **Constraints to Citrus integration**
(Mean of four farm groups)

6.2. Discussion of major Constraints to Citrus Integration.

6.2.1. Land Constraints

The finding of this study showed that predominance of small holders in the middle hill region makes integration of orange fruits difficult because of their preference to grow annual crops that meet their immediate food and cash needs. In addition to this, many small scale farm households who do not have enough homestead lands (as lands allocated for fruit trees far away from home is difficult to care and manage and not fully secured) find difficult for citrus integration. Even though, small farmers who are innovative enough to adopt citrus trees, because of the small size of land, they need to go for intercropping of food crops during early years to compensate foregone production and income from annual crops by adopting citrus fruits.

Lack of land makes many small farmers difficult for getting institutional credit as the land is a main collateral used by the institutions (e.g. Agricultural development bank) for the disbursements of the credit. Though lack of tenurial rights for cultivation is also considered one of the major factors for fruit growing, this problem was not so pronounced in the study sites.

6.2.2. Capital Constraints:

The findings from this analysis also revealed that lack of fund or capital resource is also observed as a major constraint to integration of citrus fruit particularly for the majority of marginal and small farmers. Uncertainties in the disposal of fruits make small farmers to sell their fruits to pre-harvest contractor in far below normal price. Furthermore, it is also found that farmers make contracts for selling fruits long before harvesting due to cash needs for inputs and household consumption requirements. Considerable variation was observed among small and larger farmers in the return per unit of output price received due to variation in the amount of capital owned. Large farm households received higher return as compared with small farm households as they have greater amount of working capital availability and greater access to credit for the direct marketing of fruits.

Despite, fruit farming is more profitable, it requires relatively bigger investments in the beginning and long time (5-6 years) to get expected return. This necessitates assistance for the farmers with the production and consumption credits in the absence of remunerative off-farm activities as their land used for their subsistence crop is lost. Unlike annual crops, fruit growing requires relatively high and timely availability of inputs. However, in the study sites, there is a limited availability of forest litters and compost and also the chemical fertilizers are expensive, difficult to afford and not available on time.

6.2.3. Labor Constraints:

Undoubtedly, improved farming for fruit trees such as orange is labor intensive, needs constant care and management skills to operate the orchard. However despite this, in Sankhu site, there is a low labor use in the existing orange production systems as more innovative, particularly active male members of the households who are involved in managing orange fruits were found to be involved in off-farm during off-season and also migrate seasonally to urban and other areas for off-farm work. This makes scarcity of active labor force during dry season where most of operation in citrus such as pruning, manuring, irrigation, plant protection and harvesting are carried out. Since, orange as being perennial crops require more constant labor input throughout the year than annual crops (which can be cultivated by seasonal out flow of labor in the rainy season), it is difficult to be adopted by farmers who seasonally migrate and find off-farm work more remunerative than farming in the village.

6.2.4. Marketing Constraints:

The analysis also revealed that lack of market and storage facilities for orange fruits have been found as the major constraints particularly to medium and large farmers. Because of seasonality, perishability and bulkiness of the citrus fruit, they need to be disposed off immediately after harvesting or processed into different forms like concentrates, jam, jellies, marmalades and canned fruits. Lack of suitable low cost storage technology and processing facilities have made farmers difficult even to dispose off fruits in low price during the season. The price of fruits as reported by farmers goes off 2 -3 times higher during off- season than during harvesting time. This is also a major bottlenecks to fruit integration.

Furthermore, small farmers do not have bargaining power to market their limited produce in the fair price. This has resulted less expected return from their produce hence consequently, less interest towards fruit growing. The produce cannot be transported smoothly because of rough and improper road systems.

6.2.5. Technological Constraints

Since citrus fruits are not traditional to study areas, specific knowledge and skills about planting, care and management are required for its successful cultivation. Many plant materials presently supplied by the government farms and private nurseries are also not true to type and available easily. This has specially hindered for inexperienced farmers to adopt citrus. Better citrus cultivation technology in terms of improved varieties and improved husbandry practices are almost non existent compared with cereals and other annual cash crops. Institution concerned with citrus research and development have put little concerns about its promotion in the socioeconomic circumstances of the small farmers in the hills. The research and extension service with farming systems perspective is lacking since small farmers need special skills and knowledge to integrate it into the existing systems.

6.2.6 Socio-cultural constraints:

Sociocultural factors which have been placed in security constraints in (Table 40, Figure 4) also play some role in the integration of citrus in many of the rural hill areas of Nepal.

(i). There is still social taboo in the study sites to sell and market fruit by farmers themselves. Farmers hesitate to sell their own produce in the roadside or market it by carrying in the baskets. Fruit marketing and production is still regarded inferior vocation as compared with other forms of trade and services.

(ii). Many villagers in the study site including in many mid hill areas still do not respect the right of ownerships of the ripening fruits. When tree starts bearing fruits local children and even adults do not hesitate to pick up the fruits before it is sufficiently ripe to harvests for market. There is no incentives to plant few fruit trees in many of the rural areas of Nepal. Changes in attitudes will be required to encourage farmers to invest in fruit trees.

(iii). Some farmers also do consider that free grazing of livestock is a problem for citrus integration. The costs of fencing to keep animals out of orchard is expensive and can exceed all other initial production costs.

Biophysical constraints such as climatic suitability, low soil fertility, Water availability and disease and pests are also the major factors that impede citrus integration in the existing systems. However, these factors are not analyzed as it is beyond the scope of the study and it is found that the study areas are suitable in terms of climate, soil and other biophysical factors for growing citrus fruits.

6.3 Summary

This study shows that technological information that is improvement in extension services (technical know-how) and market development could substantially attract small farmers for the integration of citrus into the existing systems. Similarly, improvement in existing credit supply policy and transaction process also expected to have significant role in the promotion of citrus since, initial capital investment and long time lag before seeing return also play important role. The constraints of labor force to care and manage, water constraints, and damage from stray animals and theft from local children, however, are not the major ones which could be alleviated through more capital investment on labor force and water supply and fencing through flexibility in credit supply and transaction.

6.4. Assessment of the benefits of the citrus integration

6.3.1. Economic Benefits

The citrus based production system has been existing since more than a decade in Sankhu site where farmers have fully integrated it into their exisitng crop based systems because of the perceived economic and financial benefits of the orange enterprise at the households. It is obvious from the views collected from households (Table 41) that orange production is highly profitable to competing crop maize in the upland. This view collected from the farmer also verifies the optimal solution of the programming model.

Table 41. Views of farm households about orange and its profitability.

No Of Respondents	%of total	Extent of profitability
33	63	Three times more profitable to maize
12	23	Two times more profitable to maize
7	14	Equally profitable as to that of maize
N = 52		

Source: Household survey, 1993

Apart from this, results of matrix ranking also substantiate the superiority of orange production to increasing farm income and improving other socioeconomic and environmental conditions as compared with existing field crops and livestock (Appendix Table 7).

6.4.2. Soil Conservation merits

It is reported that fruit trees are good for soil conservation (Nair, 1986). The empirical results suggest that orange tree at full maturity can reduce soil erosion three times more than maize crop at 5-6% slope (Phien, 1988). Sampled farmers in the study sites also do recognize the importance of tree crops in soil conservation. In view of understanding the farmers views and perception about soil conservation, sampled farmers were asked to what extent citrus trees can reduce soil erosion as compared with common competing annual crop maize. The Table 42 shows that majority of the farmers considered that orange tree can reduce soil erosion effectively when it is in full growing stage.

Table 42. Farmers perception of using citrus trees as Soil conservation measures.

Type of crop	Number of Farmer	% Farmer	Effectiveness
Orange	25	47.16	Very effective
–	20	37.77	Some effect
	8	0.15	No effect
N = 53			
Maize	10	18.86	Some effect
	22	41.50	No effect
	21	39.62	Negative effect
N = 53			

However, a very high percent of farmers view that maize crop instead of soil conserving enhances soil erosion. While few percent of farm households consider citrus has no effect on checking soil erosion. However, in case of maize, a significantly higher per cent of farmers had considered that maize has no effect on soil erosion control.

Mostly degradation of land is found to occur because of the low profitability of the existing farming systems. The experience of many farmers in Sankhu site after a decade of fruit farming revealed that use of highly profitable fruit trees like mandarin orange into the existing farming systems could reverse the degradation process because of higher cash income obtained from orange which would favor more conservation work on existing agricultural land as resource is now more valuable.
Furthermore, citrus integration can have several other social and nutritional benefits to rural farm households such as improvement in health, aesthetic pleasure to farm families and society, ecosystem stability etc. which are not accounted in this study.

CHAPTER VII

CONCLUSION AND POLICY IMPLICATIONS

7.1. Summary and Conclusion

The mid hills of Nepal, which supports nearly half of the country's population and where environmental degradation is severe, the declining production and return from the exisitng crop based systems is barely sufficient to sustain the needs of the increasing population. Considering the geoclimatic conditions, soil fertility decline and erosion from the fragile hill slopes in the mid hills, it was hypothesized that integrating a high value fruit tree such as citrus (orange) could help to improving the long term income of small farmers in the hill region of Nepal.

This study was undertaken to study both existing annual crops and integrated citrus based production systems based on the cross section data drawn from two sites: Patlekhet (annual crop based systems) and Sankhu (citrus based systems) of Kavre district in the central middle hill region of Nepal. In view of studying existing farming systems and analyzing the economic viability of citrus integration into existing crop based systems, a farm level multiperiod linear programming (MLP) technique was employed for optimum planning over a planning horizon of twenty years with and without citrus component under various economic and policy environments and resource endowments of the farm households. Farm plans were developed for each study site separately for four different groups of farms classified based on farm size. The model has been formulated to incorporate dynamic, complex and semisubsistence nature of hill farming systems by taking into consideration of economic life span of orange fruit. Though, the model is deterministic in nature, the risk averse behaviours of the small farmers are accounted through sensitivity analysis and maximizing cash income under conditions of satisfying basic household consumption and expenditure requirements. Econometric technique was employed to model the consumption behaviors of the farm house holds and incorporated it into programming model, which depended on family income and consumption units.

In the optimum farm plan of Sankhu site (study site II), the existing system with orange is compared with systems without orange by eliminating the orange component from the optimum plan. However, for the Patlekhet site (study site I), the optimum plan of existing crop based systems is compared with the improved systems with orange in the resource context of the same site by extrapolating the input-output coefficients of orange production from Sankhu site.

Apart from this quantitative analysis, a descriptive assessment of the economic and soil conservation aspects of the orange tree and the competing enterprises of the Sankhu site, is carried out and compared among them through matrix ranking (PRA) and farmers' views and responses.

The study and analysis of farming systems revealed that natural as well as human resource endowments of the sampled households were almost similar in both the study areas except citrus component in the Sankhu site. The labor and capital resource endowments of the households were found related to farm size. The realtive share of off-farm income to total family income was higher in Patlekhet even though the total absolute off-farm income was higher in Sankhu site. About 50% of the active labor force of the sampled households in the study areas were found involved in off-farm activities during slack season of the farming. The correlation analysis also revealed that there was positive relationships between farm resources and citrus area in the Sankhu site.

The results obtained from the application of multiperiod programming models indicated that the incremental benefits from the orange fruit is fairly high such that the elimination of the orange enterprize from the present farming activities at Sankhu site would cause considerable loss (12-17%) depending on farm groups. Similarly, by simulating the existing crop based systems with orange in Patlekhet site, it gave 10-15% higher return (NPVI) over the existing crop based systems in different farm groups.

The programming results also show that orange and rice are competitive crop in the range of current price ratios and production technology. However, corn, wheat and mustard are not profitable in the current price ratio, resource conditions and production technology as they do not enter in the optimum plan in all farm size groups. The smallest (group I) and largest farms (group IV) still have some land devoted for rice production, while medium sized farms (group II and III) devote all the land for orange production.

The results of the sensitivity analysis of the basic optimal plan of citrus based systems by changing the assumed key variables revealed that off-farm income is very important in the inclusion of orange in the optimal plan. Increased price of orange by > 42% and decreased discount rate by 4% make all farm groups except group I to switch from rice to orange. However, price decrease of orange by 28% and increasing discount rate by 4% make all farm groups to compeletely substitute rice to orange as orange becomes more profitable.

The programming results also revealed that orange is profitable for group III and IV (medium and large farms) even under projected yield and price decline after middle of the planning horizon. However, for group I and II the adverse situation of yield and price decline will lead the complete switching of existing orange area to rice as growing orange is not possible because of its high capital investment as compared with rice under the existng resource and technological base of the small farms.

In fully upland situation when rice is withdrawn from the model, the enterprise mix will contain only the orange and off-farm income. In the situation where off-farm labor demand and wage rate falls more than

50%, then in such case area under rice increases as farm households will not have enough fund to invest more on orange production.

There is no need of credit supply as income from off-farm is sufficient for meeting consumption requirements and investment on citrus. However, if employment in off-farm income drastically reduces, then investment in citrus fruit will not be possible without credit supply. These results demonstrate the possibility for the hill farmers to combine farm and off-farm work to achieve maximum net present value of family income under existing resource endowments and constraints of the households. The composition of enterprise mix suggested by the programming models are not far away from the one that the sample farm households in Sankhu usually do for income earning by engaging their family labor to farm (orange, rice) and off-farm work.

In addition, the results of descriptive assessment also revealed that orange is more profitable to competing enterprize maize. Besides its economic benefits, farmers also do recognize the importance of orange tree in soil conservation. The matrix ranking of the orange with other common enterprises of the locality such as maize, wheat, mustard and livestock also revealed that among all the enterprises orange is highly preferred by the farm households not only because of its higher monetary benefits but also of many other socio-economic and soil conservation merits.

Despite the potential economic benefits of orange in improving income of small farm households, its integration has not been very successful in Nepal's mid hill region. A number of socioeconomic and agronomic constraints were found to prevent farm households to adopt, integrate and expand orange into the present farm systems.

The assessment of the constraints revealed that maily the factors such as lack of technological information and poor marketing systems were impeding the integration of citrus into existing farm systems. The high initial capital investment and long time lag before seeing returns are also the major barriers to the small farmers to entering into fruit farming. However, government intervention through appropriate policies and strong institutional support services would make it possible in removing the present constraints in the integration of citrus in many mid-hill regions of Nepal.

From the results of this study, nevertheless, the study concludes that it is econmoically possible to integrate orange (citrus) into the existing crop based systems and productivity of Nepalese hill farming systems could be possibly improved if the systems are partially commercialized and integrated with perennial high value crop such as orange.

Thus, it is apparent that there is a need for policy makers to put greater emphasis on the production of citrus and citrus based production systems in the mid-hills of Nepal. This is important in view of three factors:

(a) The potentiality of citrus in augmenting family income, employment and nutrition of small farm households in the hills.

(b) A suitable fruit tree for import substitution and export promotion.

(c) As a perennial tree crop, for checking soil erosion, and maintaining ecosystem stability by utilizing marginal sloppy land.

7.2. Policy Implications of the Study

This study examines the economic consequences of two policy alternatives on long term family income and employment in Kavre district of mid-hill region Nepal. These policies are the complete specialization on traditional annual food crop -based production systems or integrating high value perennial fruits such as citrus (orange) into the existing systems. The results of the investigation both through descriptive assessment and quantitative programming technique show that;

(i). It is economically possible to increase farm household's income (NPV) through integration of orange (citrus) into existing production systems and resource endowments of the households.

(ii). Land is the most scarce resource consequently has very high shadow prices as indicated by the programming model. Its proper allocation in high pay-off enterprize such as orange is crucial in increasing farm income and sustaining poor farm households as there is no further possibility of expanding the crop acreage in the mid-hill region of Nepal.

(iii). Off-farm employment is very important for citrus integration and also the economic viability of hill farming systems. Without (or with less than 25% demand) actual off-farm employment even the large farm households would be worse off as their family income substantially dropped to invest on orange production.

(iv). Policy changes particularly changes in output price, wages and discount rate also have effect on farmers income. Improved marketing practices have greater impact than the use of improved technology (improved planting materials) which demands more use of hired labor and purchased inputs. The higher price of orange obtained from improved marketing practice would favor more conservation work on existing agricultural land as land resoure is now more valuable.

(v). Credit plays important role in the economic viability of existing citrus based farming systems only when off-farm employment is not remunerative. When existing off-farm work days in the off-season are reduced to less than 25% of the original base demand, then without credit borrowing investment on orange is not possible.

(vi). The finding of this study indicates that although emphasis on citrus based farming systems in the mid-hills area can immensely benefit the small farmers, many institutional factors could play crucial role in the success of such systems. Institutional services such as availability of disease free planting materials, purchased inputs, technical services, credit and marketing of the products are important.

(vii). This study suggests that government policies such as emphasis on fruit based farming systems and encouraging small farmers in the mid-hills to integrate citrus (orange) into existing crop based systems could benefit the small farmers more than will the present government policies which stress mainly improved cereal crop technologies.

(viii). The present land scarce and labor surplus situation in the hills of Nepal is likely to worsen in the future due to population pressure and resource degradation. The considerable and constant labor requirements of citrus fruit will make excellent use of sloppy marginal land and family labor in the slack period of the crop production cycle.

(ix). Emphasis on citrus integration is also imperative to improve country's deteriorating economy in the long run through import substitution and export promotion of orange fruit as it has comparative advantage to grow in the mid- hills of Nepal.

7.3 Limation of the Study and Further Research Areas

Despite the appropriateness and potentiality of multiperiod programming in planning the tree based production systems following limitation were visualized for further research.

(i) The construction of multiperiod linear programming model as the name implies is based upon the assumption of linear relationships among variables. However, in reality the relationships among variables may also be non linear which could not be accounted in this study.

(ii) The problem of divisibility which leads the solution to come out with decimal and small values is difficult to apply in real situation. For example land size. However, round up figure to a quarter of ropani is meaningful for farmers in the hills of Nepal since 0.25 ropani is equivalent to one matomuri and 0.1 khet muri and 1 ropani is equivalent to 16 aana. The rounding up to matomuri and khetmuri or aana provide same direction of planning except magnitude of return which however, would change. Use of dynamic integer or mixed integer programming could overcome the problem of divisibility.

(iii) Because of the long gestation period, time dimension involved in the production, heterogeniety in resource use and intertemporal profit maximization of the tree crop, the investment on fruit tree such as orange is a risky undertaking. However, in this study, due to lack of information, risk could not be incorporated directly into the model. The study only attempted to account risk factors indirectly through sensitivity analysis of lower price and yield conditions. The other forms of mathematical programming model such as quadratic programming could be used to incorporate risk directly into actual model.

(iv) Since, this study assumes that, the available land types of the farmers are homogenous in terms of quality, further research should be focussed on the quality differences in the land resources. This could be incorporated in the programming model by treating each land type quality as a different resource with its own set of activities and right hand side requirements.

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APPENDICES

Appendix Table 1. Consumers Unit and Man Equivalent index

Age of Family member (Years)	Consumer unit		Man equivalent index	
	Male	Female	Male	Female
Aged > 60	0.90	0.70	0.50	0.50
Adult (16-59)	1.00	0.80	1.00	1.00
Youth (10-15)	0.80	0.75	0.50	0.50
Children(0-9)	0.50	0.50	-	-

Source ; (EAD, 1984)

Appendix Table 2. Estimation of consumption expenditure requirements

*** Constraint Least Square Estimates**

F-Test (120, 1)	32.29
Significance of F-test	.0000
R-Squared	.18665
Adjusted R-squared	.18665

Variable	Coefficient	Std. Error	T-ratio (Sig. Lvl)	Mean of X	Std. Dev.of X
One	4025	.8353E-06	******(.0000)	1.0000	.0000
Inc.	.1127	.1067E-01	10.51(.0000)	9061.8	8389.4
Sigma	1470	94.13	15.62(.0000)		

* Inc. = Income

Appendix Table 3. Minimum consumption in NRs. (Basic needs) per household by farm size.

Year	Group I	Group II	Group III	Group IV
1	12357	16125	17227	18515
2	12480	16286	17399	18700
3	12605	16448	17573	18877
4	12731	16612	17748	19065
5	12858	16778	17925	19256
6	12986	16945	18104	19448
7	13116	17114	18285	19642
8	13247	17285	18467	19838
9	13379	17458	18651	20036
10	13512	17632	18837	20236
11	13647	17808	19025	20438
12	13783	17986	19215	20642
13	13921	18165	19407	20848
14	14060	18346	19601	21056
15	14200	18529	19797	21266
16	14342	18714	19994	21478
17	14485	18901	20193	21692
18	14629	19090	20394	21908
19	14775	19280	20597	22127
20	14922	19473	20802	22348

* Total consumption requirement per household is calculated by estimating consumption per man unit multiplied by Man equivalent index per family. The consumption requirements over the planning horizon is based on the growth of family members (consumption man units).

Table 4. Land and Labor use in different farm groups over the planning period in Sankhu (study site II).

Items	Farm size Class I		II		III		IV	
Land (ropani)	6.62		15.58		26.72		46.09	
Family labor(man days)								
Year	Peak	Slack	Peak	Slack	Peak	Slack	Peak	Slack
1	207	622	216	648	225	674	250	749
2	209	628	218	654	227	681	252	756
3	211	634	220	661	229	687	254	764
4	213	640	222	668	231	694	256	772
5	215	646	224	674	233	701	258	780
6	217	652	226	681	235	708	261	787
7	219	659	228	688	237	715	263	795
8	291	666	230	695	239	723	266	803
9	223	672	232	702	241	730	269	811
10	225	679	234	709	243	737	272	819
11	227	686	236	716	245	774	275	828
12	229	692	238	723	247	752	278	836
13	231	679	240	730	249	759	281	844
14	233	706	242	745	251	767	284	852
15	235	713	244	753	254	775	287	861
16	237	720	246	760	257	783	290	870
17	239	727	248	768	260	790	293	878
18	241	735	250	775	263	798	296	887
19	243	742	252	783	266	806	299	896
20	245	750	254	790	269	814	302	905

*Peak season = June, July, middle of November to middle of December
*Slack season = All other 9 months which are not included in peak season

Appendix Table 5. Land and Labor use in different farm groups over the planning period at study site I (Patlekhet site).

Items	Farm size Class							
	I		II		III		IV	
Land(ropani)	6.25		17.20		26.61		41.08	
Family labor(man days)								
Year	Peak	Slack	Peak	Slack	Peak	Slack	Peak	Slack
1	204	612	231	693	265	795	335	1003
2	206	618	233	700	268	803	338	1013
3	208	624	235	707	271	811	341	1023
4	210	630	237	714	274	819	344	1033
5	212	636	239	720	277	827	347	1044
6	214	642	241	728	280	835	350	1054
7	216	648	243	735	283	844	353	1065
8	218	655	245	743	239	853	357	1075
9	221	667	247	750	286	861	361	1086
10	223	674	249	758	289	869	364	1100
11	225	680	251	766	292	887	368	1108
12	227	687	253	773	295	896	372	1119
13	230	694	255	781	301	905	375	1130
14	232	701	257	789	304	914	379	1141
15	234	708	259	797	307	923	383	1153
16	237	715	261	804	310	932	386	1164
17	239	722	263	813	313	942	390	1176
18	241	729	265	821	316	951	394	1188
19	244	737	267	829	310	960	398	1199
20	246	743	269	837	321	970	402	1211

*Peak season = June, July, middle of November to middle of December

*Slack season = All other 9 months which are not included in peak season

Appendix Table 6. Gross margin and labor Use in existing orange production (on per tree basis)

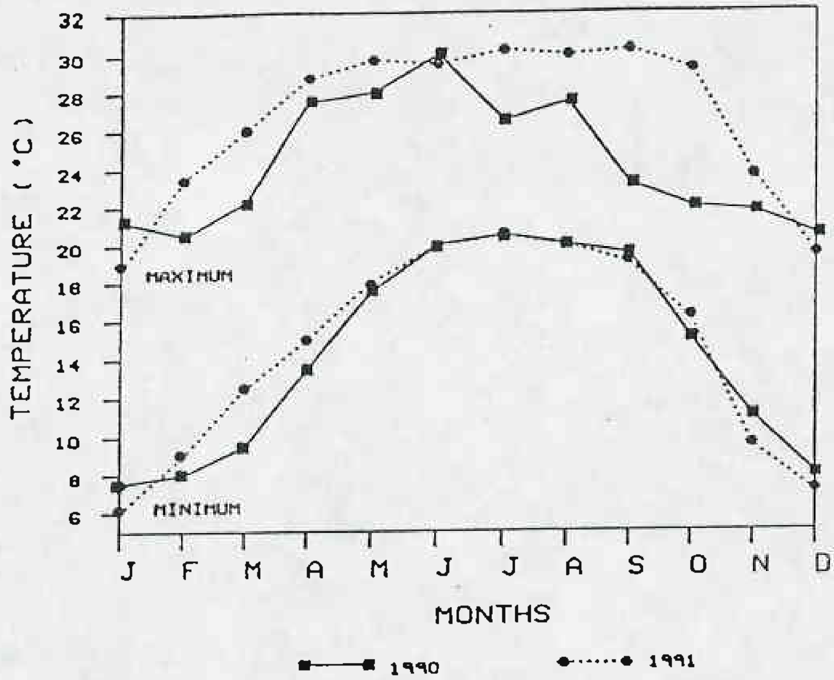
Year	Yield (kg/tree)	Gross revenue (NRs./tree)	Input costs (NRs./tree)	Labor Use (M days/tree)	Gross margin (NRs./tree)
1	0	0	13	0.42	-13
2	0	0	5.5	0.15	-5.5
3	0	0	6	0.16	-6.0
4	0	0	8	0.17	-8.0
5	0	0	9	0.19	-9.0
6	3	21	10.75	0.21	10.25
7	7	49	12	0.23	37
8	13	91	16.5	0.27	74.5
9	19	133	20	0.28	113
10	23	161	20	0.28	141
11	25	175	20	0.28	155
12	27	189	20	0.28	169
13	28	196	20	0.28	176
14	26.5	187.6	20	0.28	167.6
15	26	182	20	0.28	162
16	25.4	177.8	20	0.28	157.8
17	24.8	173.6	18	0.25	146.5
18	24.5	171.5	18	0.25	157
19	24	168	18	0.25	150
20	23.5	164.5	18	0.25	143

* Price = NRs 7/kg of fruits.

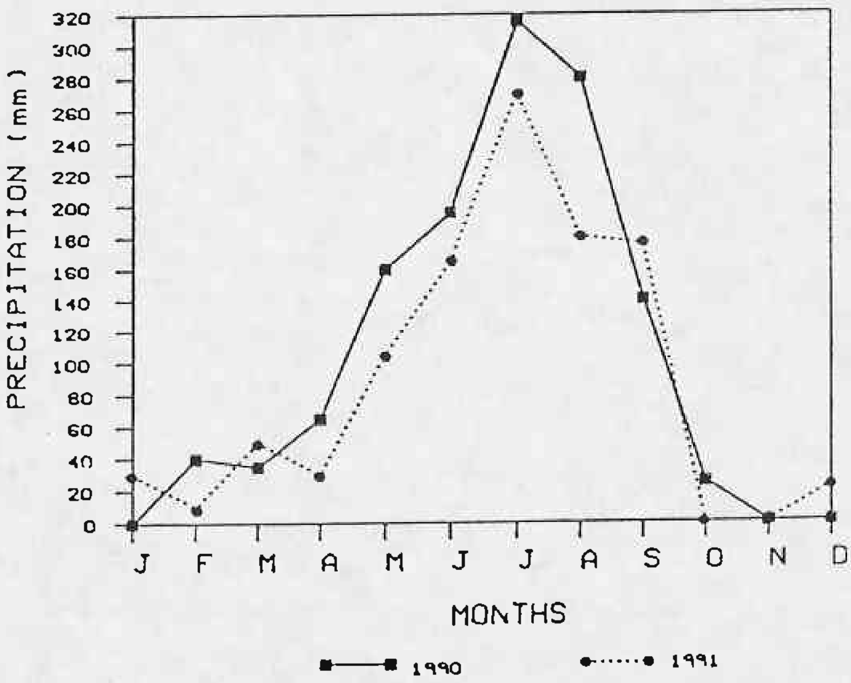
Appendix Table 7. Matrix Ranking for Citrus fruit against Other production systems

Items	Citrus Fruits	Livestock	Maize	Wheat	Mustard
Income	1	2	4	5	3
Less Labor Requirement	2	4	5	3	1
Easy to get credit	1	2	3	3	3
Techn. Knowledge	5	4	1	3	2
Market	1	2	4	5	3
Social & Environ. benefits	1	3	4	5	2
Over all preference Total	1	3	5	4	2

Note : The rank 1 is the most preferred followed by 2,3,4 and 5 is the least preferred one.



APPENDIX FIGURE 1 . Monthly temperature distribution for Bela, 1990 & 1991.



APPENDIX FIGURE1 Monthly rainfall distribution for Bela, 1990 & 1991.

JIKHIKHOLA WATERSHED , KAVRE

Source: ICIMOD, 1993

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