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 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			
	LN1	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		
	LD2					1					
	LP2					3.33					
	LN2					1.16					
	CR2										
	CE2										
	KB2					-176			-0.16		1
	.					.			.		
	.					.			.		
YEAR 8	GM8					2384			-0.16		
	LD8					1					
	LP8					5.24					
	LN8					2.82					
	CR8										
	CE8										
	KB8					2384			-0.16		
	.					.					
	.					.					
YEAR 20	GM20					4688					
	LD20					1					
	LP20					4.87					
	LN20					2.62					
	CR20										
	CE20										
	KB20					4688					

	OBJ:	YEAR 2 RC2	WT2	CN2	MT2	OR2	OF2	LH2	CB2	CA2	CT2 • •
YEAR 1	PNV										
	GM1										
	LD1										
	LP1										
	LN1										
	CR1										
	CE1										
	KB1										
YEAR 2	GM2	919	174	156	402	-1056	60	-60			
	LD2	1	1	1	1	1					
	LP2	9.75	2.3	3.15	1.25	11.56		-1			
	LN2	0.6	2.25	4.7	1.7	1.16	1				
	CR2					1056			-1		
	CE2									1	
	KB2	919	174	156	402	-1056	60	-60	1	-1	-1
	.					.			.		• •
	.					.			.		
YEAR 8	GM8					1184			-0.16		
	LD8					1					
	LP8					5.63					
	LN8					3.63					
	CR8					.					
	CE8										
	KB8					1184			-0.16		1 • • •
	.					.					
	.					.					
YEAR 20	GM20					4800					
	LD20					1					
	LP20					4.87					
	LN20					2.62					
	CR20										
	CE20										
	KB20					4800					• • •

	OBJ:	YEAR 8 RC8	WT8	CN8	MT8	OR8	OF8	LH8	CB8	CA8	CT8 . . . . .
YEAR 1	PNV										
	GM1										
	LD1										
	LP1										
	LN1										
	CR1										
	CE1										
	KB1										
YEAR 2	GM2										
	LD2										
	LP2										
	LN2										
	CR2										
	CE2										
	KB2										
	.										
	.										
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			
	LN8	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					
	LN20					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
LN = 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

		YEAR 20										Gross Margin Accounting in different Years of the Planning period							
	OBJ:	RC20	VT20	CN20	MT20	OR20	OF20	LH20	CB20	CA20	CT20	YEAR 1 GM1	YEAR 2 GM2	. . .	YEAR 8 GM8	. . .	YEAR 20 GM20	SIGN	RHS
	PNV											1	0.862069	. . .	0.35383	. . .	0.059607	=	0
YEAR 1	GM1											-1						=	0
	LD1																	<	6.68
	LP1																	<	207
	LW1																	<	622
	CR1																	>	0
	CE1											-0.1122						>	12357
	KB1																	=	0
	GM2												-1					=	0
YEAR 2	LD2																	<	6.68
	LP2																	<	209
	LW2																	<	628
	CR2																	>	0
	CE2												-0.1122					>	12480
	KB2																	=	0
	.																	.	.
	.																	.	.
	GM8														-1			=	0
YEAR 8	LD8																	<	6.68
	LP8																	<	225
	LW8																	<	666
	CR8																	>	0
	CE8														-0.1122			>	13247
	KB8																	=	0
	.																	.	.
	.																	.	.
	GM20	919	174	156	402	-1056	60	-60									-1	=	0
YEAR 20	LD20	1	1	1	1	1												<	6.68
	LP20	9.75	2.3	3.15	1.25	11.56		-1										<	243
	LW20	0.6	2.25	4.7	1.7	1.16	1											<	750
	CR20					1056			-1									>	0
	CE20									1							-0.1122	>	14922
	KB20	919	174	156	402	-1056	60	-60	1	-1	-1							=	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.