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Benefit-cost analysis of existing and improved agroforestry systems in mid-hill zone of Himachal Pradesh

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ABSTRACT

The present study was conducted in Sirmaur district of mid-hill zone of Himachal Pradesh to evaluate benefit and cost of existing `Agri-pastoral-horti-silviculture (APHS) system' and improved agroforestry system. Under all farm situations the gross income was estimated as Rs 4.20 lakhs. At overall level the net income of the system turned out to Rs 2.38 lakhs in the study area agriculture being the major contributor followed by pastures, horticulture and forestry. Total cost incurred on components of system was 1.82 lakhs. The comparative economics of existing and new agroforestry technology showed that there existed a scope of increasing Rs 29722 per ha as an incremental income from new agroforestry technology over existing practice for pasture/grassland areas under an average situation.

Keywords: Agri-pastoral-horti-silviculture system; partial budgeting; grassland

INTRODUCTION

In Himachal Pradesh the agroforestry systems have been practiced since millennia and passed from generations to generations. These systems were built on the foundation of protecting and planting trees. It is these systems which in the past have made hill people self-sufficient and well nourished. Leakey (2001) suggested that agroforestry is now being seen as an alternative paradigm for rural development worldwide that is centered on species-rich and low-input agricultural techniques including a diverse array of new indigenous tree crops rather than on high-input monocultures with only a small set of staple food crops. However these systems need to be improved and moulded into a well developed and sustainable form through the use of scientific methods, ecological and management principles, agronomic research etc so that they can contribute to livelihood, ensure food security and generate economic benefits to the farming community. Different agroforestry mixed farming systems exist in various regions of the state depending upon the density of

plantation, existence of traditional/exotic tree species, naturally regenerated/manually planted trees and other local circumstances. In most cases trees are naturally grown spread on fields. But now a days only few are being replaced and are in danger of disappearing due to socio-economic and demographic conditions. Thus studies directed towards these determining factors would add to the better understanding and management of land use systems. The main aim of this study was to provide an understanding of type of the system, technology used, resource requirements and profitability.

METHODOLOGY

The study was conducted in Sirmaur district of mid-hill zone of Himachal Pradesh which is situated in between 800-1600 meters amsl and has latitude and longitude 30°22¹30º to 31°01¹20º North and 77°01¹12º to 77°49¹40º East respectively. Narag village was selected as nucleus village where agroforestry practices were more predominant. Three adjoining villages were also chosen to form a cluster of 4 villages. The cluster so formed in the district well represented farming practices being followed in the zone in general. After forming the village cluster a list of households was procured. Thereafter the households were classified into 3 groups viz small, medium and large depending upon operational size of holding as per agriculture census. The marginal and small farm categories were clubbed together. The small farmers were those having land holding up to 2 ha, medium 2-3 ha and large above 3 ha. In total a sample of 30 households was drawn for conducting present study. Primary data were collected on specially designed schedules from the selected households by adopting personal interview method. Secondary data were obtained from government offices such as village Panchayat, revenue office and the Dr YS Parmar University of Horticulture and forestry, Nauni, Solan.

The cost and return analysis of the existing agroforestry systems was carried out using tabular analysis. The valuation of free livestock grazing was done using indirect substitute approach. The adult cattle unit (ACU) was worked out by using the equivalent given by Yang (1971). The imputed prices of all the products were determined on the basis of market price of a product minus labour and transportation cost. The value of these products was determined by multiplying quantity of their annual harvest with the imputed price of respective product. The imputed value of family labour, bullock labour, FYM and other farm by-products, tree fodder and grasses was estimated using opportunity cost method or shadow pricing method.

RESULTS and DISCUSSION

The farming system changes both within and across physical environments

depending upon resources available to the farmers and needs of their family. In hilly areas crops and livestock combinations vary within very short distances because of the pronounced differences in agro-climatic conditions. This results into different types of farming systems. The structural and operational features of the existing agroforestry farming system prevalent in the study area are described.

Characteristics of sample farmers

The sample farmers were stratified into three categories as per the total land holding. The small farmers had an average land holding of 1.216 ha, medium farmers had 2.261 ha while large farmers had 3.470 ha. Thus the overall holding size of the sample farmers in the study area was 2.405 ha.

Identification of existing agroforestry system

The existing farming system in the selected area was typified and identified based on the income generated by different sub-sectors of the system like food grains, vegetables, horticulture, livestock and farm forestry activities. The livestock income has been accounted for in the pastoral sub-component of the system because of high dependency of livestock on grasslands in the hilly areas. Agricultural crop sector was contributing maximum proportion towards total farm income in the study area followed by livestock and pasture, horticulture and forestry sub-sectors. Therefore the system could be designated as agri-pastoral-horti-silviculture (APHS) system in the study region. In 2012-13 in overall level per household agricultural income was Rs 126278 and this constituted 52.96 per cent of total farm income. This income was highest (59.77%) on large farms and lowest Rs 92300 on small farms (49.23%). The second important contributor towards total farm income was livestock and pasture sub-component in the study area whose contribution ranged between 18.36 per cent (large farms) and 39.43 per cent (small farms) and in average situation it accounted for 28.39 per cent of total farm income. Horticulture sector on an average contributed nearly 10 per cent and the contribution of forestry sector was estimated 8.33 per cent of total farm income (Table 2).

Land availability and use

Land use pattern: The pasture/grassland accounted for about 61.41 per cent of the total farm holding which was highest among all other farm size groups. The land under agricultural crop shared 36.34 per cent of the total holding at on an average farm. However share of cultivated land varied from 31.57 (medium farms) to 45.64 per cent on small farm category. It was also found that 5.90 per cent of cultivated land in identified system was irrigated at overall level. The area under non-agricultural land comprised of 1.71 per cent while orchard area constituted only 0.54 per cent of total land holding on an average (Table 3).

Table 1. Composition of sample farmers

Category	Number	Average holding size (ha)
Small	10	1.216
Medium	10	2.261
Large	10	3.470
Total	30	2.405

Table 2. Net farm income from different farm activities of existing agroforestry systems under various categories of agroforestry farms

Source of income	Income from different size of agroforestry systems (Rs)			
	Small (<2 ha)	Medium (2-3 ha)	Large (>3 ha)	Overall
Agriculture	92300.62 (49.23)	129211.10 (48.82)	157322.61 (59.77)	126278.11 (52.96)
Horticulture	13098.00 (6.99)	31676.00 (11.97)	28981.00 (11.01)	24585.00 (10.31)
Forestry	8165.00 (4.35)	22867.80 (8.64)	28587.00 (10.86)	19873.27 (8.33)
Pasture and livestock	73923.00 (39.43)	80890.20 (30.57)	48314.75 (18.36)	67720.98 (28.40)
Total	187486.62 (100.00)	264645.10 (100.00)	263205.36 (100.00)	238457.36 (100.00)

Figures in the parentheses represent the percentages to the respective figures

Table 3. Land utilization pattern of sampled agroforestry farms

Land type	Land use (ha) under different categories			
	Small	Medium	Large	Overall
Cultivated land	0.555 (45.64)	0.840 (31.57)	1.228 (35.39)	0.874 (36.34)
Irrigated	0.176 (14.47)	0.120 (4.51)	0.130 (3.75)	0.142 (5.90)
Unirrigated	0.379 (31.17)	0.720 (27.06)	1.098 (31.64)	0.732 (30.44)
Orchard area	0.008 (0.66)	0.032 (1.20)	-	0.013 (0.54)
Pasture/grassland	0.597 (49.09)	1.749 (65.73)	2.086 (60.12)	1.477 (61.41)
Non-agricultural land	0.024 (1.97)	0.040 (1.50)	0.060 (1.73)	0.041 (1.71)
Leased-in land	-	0.032 (1.20)	-	0.011 (0.46)
Leased-out land	0.032 (2.63)	-	0.096 (2.77)	0.043 (1.79)
Total holding	1.216	2.661	3.470	2.405

Figures in the parentheses represent the percentages to the respective figures

Fragmentation of holdings: On an average the number of fragments of cultivated land was 4, 5 and 6 for small, medium and large category farms respectively. The corresponding figures for pasture/grassland were 3, 4 and 4 respectively. In totality the average number of plots together for cultivated lands and pasture land worked out to 7, 9 and 10 for small, medium and large farmers respectively. At overall level the total number of plots which each farmer had been processing numbered at 8.67 comprising of 5 plots under cultivated and 3.67 plots under pasture/grassland (Table 4).

Crop diversification: The important cereal crops under agri-pastoral-horti-silviculture system were maize, wheat and barley. Vegetable crops grown included tomato, capsicum, beans and green peas. It was found that of the gross cropped area the area under vegetables comprised of 46.65 per cent followed by cereals (42.99%), black gram (1.14%) and mustard (0.13%) in overall situation. The area under agroforestry plantation was estimated to be 8.21 per cent which was scattered on the boundaries of fields normally grown with other crops. The cropping intensity of agroforestry system came out to be 178.58 per cent in overall situation which was found highest on small farms (187.92%) and lowest of on large farms (174.43%) (Table 5).

Domestication of tree plantation: On the average farmers were maintaining around 100 trees in existing agroforestry system out of which 45 per cent were on cultivated land and 55 per cent on grassland. The number of forestry trees was positively related with size of farm. Primary purpose of maintaining forest trees on farms was to augment income to meet out fodder, fuel and small timber for implements and hand tools. Sharma and Tewari (1999) worked out the financial feasibility of growing wild pomegranate of the farmers of middle hills of western Himalayas. The crop was found to contribute 31-40 and 55-75 per cent towards net cash and farm forestry income respectively on the mid-hill farms.

Among the trees Bhimal was most favoured fodder tree which accounted for 11.50 per cent at overall level. Wild pomegranate (*Punica granatum*) which is one of the important cash crops of the area accounted for 31.60 per cent of total tree plantation. Khair was another important forest tree which shared about 12 per cent of total forestry plantation and was used not only as a fodder and fuelwood tree but also augmented the income from Katha extraction out of it. Inventory of forest trees maintained in cultivated land and grasslands is presented in Table 6. The density of trees per hectare was worked out to be about 42 trees on an average situation. On grassland density ranged between nearly 34 plants per hectare on medium farms and about 45 plants on small farms. In overall level density of plantation was found more in cultivated land than in grassland (Table 6).

Table 4. Average number of plots and size of each plot in different size of farms

Farm category	Cultivated land		Pasture/grassland		Total	
	# plots	Average plot size (ha)	# plots	Average plot size (ha)	# plots	Average plot size (ha)
Small	4	0.141	3	0.199	7	0.165
Medium	5	0.174	4	0.437	9	0.291
Large	6	0.205	4	0.522	10	0.332
Overall	5	1.73	3.67	0.386	8.67	0.263

Table 5. Cropping pattern on sample farms (%)

Crop	Small	Medium	Large	Overall
Kharif crops				
Maize	14.65	15.39	20.68	17.61
Tomato	20.23	15.58	15.45	16.54
Capsicum	11.15	7.92	7.00	8.21
Beans	0.00	3.99	1.31	1.89
Black gram	0.76	0.97	1.40	1.14
Fallow land	0.00	4.44	0.28	1.58
Sub-total	46.79 (0.495)	48.29 (0.750)	46.13 (0.988)	46.97 (0.744)
Rabi crops				
Wheat	19.75	18.03	10.64	15.09
Barley	5.29	12.88	10.92	10.29
Peas	21.74	17.38	21.00	20.01
Mustard	0.00	0.00	0.37	0.13
Fallow land	0.00	0.00	3.17	1.45
Sub-total	46.79 (0.495)	48.29 (0.750)	46.13 (0.988)	46.97 (0.744)
Perennial crops				
Orchards	0.76	2.06	0.00	0.82
Aagroforestry	5.67	5.80	11.20	8.21
Sub-total	6.43 (0.068)	7.86 (0.122)	11.20 (0.240)	9.03 (0.143)
Gross cropped area (ha)	1.058 (100.00)	1.553 (100.00)	2.142 (100.00)	1.584 (100.00)
Cropping intensity (%)	187.92	178.10	174.43	178.58

Benefit-cost of agroforestry systems Table 6. Inventory of forest trees maintained in cultivated land and grassland (#)

Tree species	Farm size											
	Small			Medium			Large			Overall		
	CL	GL	Total	CL	GL	Total	CL	GL	Total	CL	GL	Total
Wild pomegranate	12	4.5	16.5 (33.9)	20.0	6.6	26.6 (28.27)	40.0	12.0	52.0 (33.41)	24.0	7.7	31.7 (31.60)
Bhimal	5	1.3	6.3 (12.1)	7.0	3.6	10.6 (11.26)	15.0	2.5	17.5 (11.24)	9.0	2.5	11.5 (11.46)
Tooni	2	0.2	2.2 (4.51)	1.0	1.0	2.0 (2.13)	3.0	1.5	4.5 (2.89)	2.0	1.0	3.0 (2.99)
Khirak	2	1.3	3.3 (6.78)	3.0	1.5	4.5 (4.78)	6.0	2.6	8.6 (5.53)	3.67	1.8	5.47 (5.45)
Kainth	-	-	-	-	3.0	3.0 (3.19)	1.0	3.5	4.5 (2.89)	0.33	2.17	2.5 (2.49)
Pear	1	-	1.0 (2.1)	1.0	-	1.0 (1.06)	3.0	-	3.0 (1.93)	1.67	-	1.67 (1.66)
Bani	-	1.4	1.4 (2.87)	1.0	1.3	2.3 (2.44)	2.0	4.3	6.3 (4.05)	1.0	2.33	3.33 (3.32)
Chir	-	8.8	8.8 (18.1)	-	27.0	27.0 (28.69)	1.0	-	29.5 (18.96)	0.67	21.43	22.1 (22.04)
Kachnar	-	2.4	2.4 (4.93)	-	3.0	3.0 (3.19)	-	-	6.0 (3.86)	-	3.8	3.8 (3.78)
Khair	-	6.2	6.2 (12.73)	-	11.0	11.0 (11.69)	1.0	-	18.0 (11.57)	0.33	11.4	11.73 (11.69)
Albizzia	-	0.2	0.2 (0.41)	-	0.5	0.5 (0.53)	1.0	-	1.8 (1.16)	0.33	0.5	0.83 (0.82)
Kakkar	-	0.2	0.2 (0.41)	-	0.4	0.4 (0.43)	1.0	-	1.4 (0.89)	0.33	0.33	0.66 (0.65)
Paza	-	0.2	0.2 (0.41)	-	0.2	0.2 (0.21)	-	-	0.5 (0.32)	-	0.33	0.33 (0.32)
Shahtoot	-	-	-	1.0	-	1.0 (1.06)	1.0	-	1.0 (0.64)	0.67	-	0.67 (0.66)
Fig	-	-	-	1.0	-	1.0 (1.06)	1.0	-	1.0 (0.64)	0.67	-	0.67 (0.66)
Walnut	-	-	-	-	-	-	1.0	-	1.0 (0.64)	0.33	-	0.33 (0.32)
Total												
Per farm	22.00	26.70	48.70	35.0	59.0	94.10	77.0	79.6	155.6	45.0	55.26	100.29
Per ha	40.86	44.72	40.85	40.13	33.73	35.90	62.70	38.15	45.63	50.13	37.41	42.4

CL= Cultivated land, GL= Grassland

Figures in the parentheses represent the percentages to the respective figures

Labour availability and use

Family labour was the most important source of labour in the region under study. However farmers did hire labour during the peak demand periods. An average family hired only a total of 35 man days per annum. The livestock and pasture sector employed the maximum percentage of the total labour force engaged in the system. Agriculture sub-sector of the system was found next important component employing nearly 34 per cent of labour at overall level. Forestry and horticulture individually engaged 7.62 and 6.32 per cent of the total labour used in the system (Table 7).

Livestock holding

Livestock composition: On the average farmers kept 2.3 cows, 0.23 buffaloes, 1.54 bullocks, 2.07 young stocks, 0.87 goat and sheep with the total number of livestock to be 7.04 animals. In terms of adult cattle units the total number comes out to be 5.9 units at overall level. The number of adult cattle unit was highest on medium farms ie 6.1 cattle units and 5.75 cattle units on small and large farms (Table 8).

Grazing pattern of animals: The farmers in study area had to resort to grazing activity due to insufficient availability of fodder to animals. Grazing was practiced in common property forest, grassland and even in cultivated land after harvesting to meet the shortfalls in the fodder availability. Under overall situation nearly 73 per cent of livestock reared by sampled farms might resort to grazing practice (Table 9).

Economics of existing agroforestry system

Gross farm income: Under all farm situations the gross income was estimated as Rs 4.20 lakhs. It was worked out Rs 3.17, Rs 4.55 and Rs 4.87 lakhs on small, medium and large farm categories respectively. In the five sub-Sahara African case studies Franzel and Scherr (2002) found that agroforestry had potential to increase farm incomes and solve difficult environmental problems. It was financially more profitable to local farmers in comparison to traditional cultivation besides its other economic and social benefits.

Farm expenses: The total cost incurred on various components of the system on small, medium and large farms was estimated at Rs 1.30, Rs 1.91 and Rs 2.24 lakhs respectively. Of the total costs the share of variable costs was 61.09, 68.36 and 68.98 per cent on small, medium and large farms respectively. The corresponding share of fixed costs in the total costs was 38.91, 31.64 and 31.02 per cent.

Gross margins: The return over variable cost (ROVC) was estimated Rs 2.99 lakhs for an average farm of the study region for the whole system. The gross margin ranged between Rs 2.38 (small farms) and Rs 3.33

Table 7. Per household source-wise level of on-farm employment in mid-hill zone of HP (man days/annum)

Source of employment	Category			
	Small	Medium	Large	Overall
Agriculture	113.00 (32.90)	144.00 (32.18)	203.00 (36.74)	154.00 (34.33)
Horticulture	15.00 (4.37)	32.00 (7.15)	38.00 (6.88)	28.33 (6.32)
Forestry	18.50 (5.38)	29.50 (6.59)	54.60 (9.88)	34.20 (7.62)
Pasture and livestock	197.00 (57.35)	242.00 (54.08)	257.00 (46.50)	232.00 (51.72)
Total	343.50 (100.00)	447.50 (100.00)	552.60 (100.00)	448.53 (100.00)

Figures in the parentheses represent the percentages to the respective figures

lakhs (large farms). The component-wise breakup of ROVC revealed that the share of agriculture turned out to be highest (52.05%) followed by livestock and pastures (32.79%), horticulture (8.47%) and forestry (6.69%) of the total gross margins of the system.

Net income: At overall level the net income of the system turned out to be Rs 2.38 lakhs agriculture being the major contributor followed by pastures, horticulture and forestry. The share of net profit from agriculture was largest on large farms (59.77%) followed by small (49.23%) and medium farms (48.82%) in the total net income of the whole system. The corresponding figures to pasture sub-sector were 18.36, 39.43 and 30.57 per cent. The proportion of net profit earned by horticulture was highest on medium farms and lowest on small farms. In forestry sector net profit was found highest on large farms followed by medium and small farms. Kurtz (2000) analyzed that agroforestry provided cost-effective alternatives that could increase profits and meet environmental goals (Table 10).

Comparative economics of existing and improved agroforestry practices for pasture/grassland

Pastures/grasslands occupy large proportion of the total farm land holding in the study region. Making this land more productive can enhance socio-economic wellbeing of the farmers.

Dr YS Parmar University of Horticulture and forestry, Nauni has developed the agroforestry technology for the pasture/grassland integrating *Grewia optiva* and *Morus alba* with Setaria. The tree species are planted at a spacing of 0.5 × 0.75 meter involving gradonii soil working technique (60 cm width × 20 cm uppercut × 12-24 m long) depending upon the terrain. *M alba* and *G optiva* trees are

Table 8. Average livestock inventory on sampled households

Category	Livestock													
	Cow		Buffalo		Bullock		Young stock		Goat and sheep		Horse		Adult cattle unit	
	#	Value	#	Value	#	Value	#	Value	#	Value	#	Value	#	Value
Small	2.20 (27.85)	39500	0.20 (2.53)	10000	1.60 (20.25)	5200	1.5 (18.99)	1900	2.3 (29.11)	12900	0.1 (1.27)	3000	5.75	72500
Medium	2.40 (34.29)	80000	0.20 (2.86)	10000	1.20 (17.14)	4200	2.9 (41.43)	3400	0.3 (4.28)	1800	-	-	6.10	99400
Large	2.30 (37.10)	54500	0.30 (4.84)	15000	1.80 (29.03)	6400	1.8 (29.03)	3200	-	-	-	-	5.75	79100
Overall	2.30 (32.68)	58000	0.23 (3.28)	11667	1.54 (21.88)	5267	2.07 (29.41)	2833	0.87 (12.35)	4900	0.03 (0.005)	1000	5.90	83667

Figures in the parenthesis represent the percentages to the total respective figures

Table 9. Grazing pattern of livestock in mid-hill sampled agroforestry farms

Grazing source	# animals	Grazing period	Grazing area (ha)	Graziers (%)		# animals	Grazing period	Grazing area (ha)	Graziers (%)	
				M	F				M	F
		Small farm					Medium farm			
Cultivated land after harvesting	6.9	Oct-Nov	0.563	11.11	88.89	4.2	Oct-Nov	0.872	-	100
Grassland	6.9	Nov-May	0.597	44.44	55.56	4.2	Nov-May	1.749	66.67	33.33
Permanent pasture/ Forest	6.9	Jun- Sept	9.90	55.56	44.44	4.2	Jun- Sept	9.90	66.67	33.33
		Large farm					Overall			
Cultivated land after harvesting	4.7	Oct-Nov	1.228	37.5	62.50	5.27	Oct-Nov	0.887	20.00	80.00
Grassland	4.7	Nov-May	2.086	87.50	12.50	5.27	Nov-May	1.477	65.00	35.00
Permanent pasture/ forest	4.7	Jun- Sept	9.90	87.50	12.50	5.27	Jun- Sept	9.90	70.00	30.00

Table10. Income and cost analysis of different components of agroforestry system under various categories of agroforestry farms in the study area

Size/ Component	Gross income	Fixed costs	Variable costs	Total costs	Gross margins	Net income
Small						
Agriculture	151295.68 (47.63)	21657.50 (42.77)	37337.56 (46.96)	58995.06 (45.33)	113958.12 (47.86)	92300.62 (49.23)
Horticulture	15083 (4.75)	94.00 (0.19)	1891.00 (2.38)	1985.00 (1.53)	13192 (5.54)	13098.00 (6.99)
Forestry	11713.00 (3.69)	50.00 (0.09)	3498.00 (4.39)	3548.00 (2.73)	8215.00 (3.45)	8165.00 (4.35)
Livestock & pasture	139544.00 (43.93)	28835.00 (56.95)	36786.00 (46.27)	65621.00 (50.42)	102758.0 (43.15)	73923.00 (39.43)
Total	317635.68 (100.00)	50636.5 (100.00)	79512.56 (100.00)	130149.06 (100.00)	238123.12 (100.00)	187486.62 (100.00)
Medium						
Agriculture	203301.00 (44.62)	27849.11 (46.11)	46240.79 (35.43)	74089.90 (38.81)	157060.21 (48.47)	129211.10 (48.82)
Horticulture	37611 (8.26)	2100.12 (3.48)	3835.40 (2.94)	5935.52 (3.11)	32776.12 (10.11)	31676.00 (11.97)
Forestry	27511.93 (6.04)	144.13 (0.24)	4500.00 (3.45)	4644.13 (2.43)	23011.93 (7.10)	22867.80 (8.64)
Livestock & pasture	187144.80 (41.08)	30307.60 (50.18)	75947.00 (58.19)	106254.6 (55.65)	111197.8 (34.32)	80890.20 (30.57)
Total	455569.25 (100.00)	60400.96 (100)	130523.19 (100.00)	190924.15 (100.00)	324046.06 (100.00)	264645.1 (100)
Large						
Agriculture	260354.00 (53.39)	38082.27 (53.94)	64949.12 (41.95)	103031.39 (45.91)	195404.88 (58.72)	157322.61 (59.77)
Horticulture	34481.00 (7.08)	102.00 (0.14)	5398.00 (3.49)	5500.00 (2.45)	29083.00 (8.74)	28981.00 (11.01)
Forestry	32446.87 (6.65)	214.87 (0.31)	4645.00 (3.00)	3859.87 (1.72)	27801.87 (8.36)	28587.00 (10.86)
Livestock & pasture	160349.00 (32.88)	32197.25 (45.61)	79837.00 (51.56)	112034.25 (49.92)	80512.00 (24.18)	48314.75 (18.36)
Total	487630.87 (100.00)	70596.39 (100.00)	154829.12 (100.00)	224425.51 (100.00)	332801.75 (100.00)	263205.36 (100.00)
Overall						
Agriculture	204983.40 (48.74)	29493.09 (48.48)	49212.20 (40.56)	78705.29 (43.20)	155771.20 (52.05)	126278.11 (52.96)
Horticulture	29058.5 (6.91)	765.37 (1.26)	3708.13 (3.06)	4473.50 (2.46)	25350.37 (8.47)	24585.00 (10.32)
Forestry	24223.93 (5.76)	136.33 (0.22)	4214.33 (3.47)	4350.66 (2.39)	20009.60 (6.69)	19873.27 (8.33)
Livestock & pasture	162357.6 (38.59)	30446.62 (50.04)	64190.00 (52.91)	94636.62 (51.95)	98167.60 (32.79)	67720.98 (28.39)
Total	420623.43 (100.00)	60841.41 (100.00)	121324.66 (100.00)	182166.07 (100.00)	299298.77 (100.00)	238457.36 (100.00)

Figures in the parenthesis represent the percentages to the total respective figures

Table 11. Estimated additional returns from improved agroforestry technology using partial budgeting technique for grassland/pasture component of the system

Particulars	Existing practice	Improved practice
Gross returns (Rs/ha)	21454	56000
Costs involved (Rs/ha)	7650	12474
Net income	13804	43526

A	B
Added costs= 12474	Added returns= 56000
Reduced returns= 21454	Reduced costs= 7650
Total= 33928	Total= 63650

Incremental income= 63650 - 33928= Rs 29722

pollarded at 0.5 and 1.5 m height respectively. The system yielded about 40-50 q/ha of leaf fodder. In addition to it improved variety of Setaria can produce 3.5-4.5 tons grass on per ha basis. The soil working and plantation establishment cost involved in the system is approximately amounting to around Rs 30000 to Rs 40000 on per ha basis depending upon slope and site. New technology can increase the income of farmers appreciably as with the help of this technology farmers can opt for dairy enterprise. Plantation activity conducted using Gradonii technology will help considerably in controlling the soil erosion and recharging the deeper soil layers.

The per ha net returns from pasture component of the system with improved agroforestry technology was worked out to be more than three times over the existing practice followed by the sample farmers. The per hectare incremental income turned out to be Rs 29722 from the improved agroforestry method. The results obtained from the analysis indicated that there existed ample scope of increasing the farm income of the sample farmers through the introduction of this improved practice. Tewari (1985) estimated the economics of various agroforestry systems by introducing *Leucaena leucocephala* in the existing cropping system of lower hills of Himachal Pradesh and concluded that per hectare net return could be increased up to three times (Rs 598.62) by adopting agri-silviculture system in comparison to existing cropping systems. However the adoption of agri-silvi-pastoral system increased the net returns to Rs 1350.69.

CONCLUSION

It was concluded that gross income of the system was estimated as Rs 4.20 lakhs. It was worked out to be Rs 3.17, Rs 4.55 and Rs 4.87 lakhs on small, medium

and large farm categories respectively. The total cost incurred on various components of the system on small, medium and large farms was estimated at Rs 1.30 l, Rs 1.91 and Rs 2.24 lakhs respectively and 1.82 lakhs at overall level. Net income of the system estimated was Rs 2.38 lakh agriculture being the major contributor (52.96%) followed by livestock and pastures (28.39%), horticulture (10.32%) and forestry (8.33%). By comparing the economics of existing and improved agroforestry technology per ha net returns from pasture component of the system with improved agroforestry technology was worked out to be more than three times over the existing practice followed by the sample farmers. Per hectare incremental income turned out to be Rs 29722 from the improved agroforestry practices.

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