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Bio-Economic Appraisal of Agroforestry Systems in Dry Temperate Western Himalayas

Kafula Chisanga , DR Bhardwaj[1], and Subhash Sharma[2]

Soils and Water Management Division, Agroforestry Unit, Zambia Agriculture Research Institute (ZARI), P.O.Box 630090 CHOMA, ZAMBIA; [1] Dept. of Silviculture and Agroforestry; [2] Dept. of Social Sciences Dr. YS Parmar University of Horticulture & Forestry, Nauni, Solan, HP-173230

ABSTRACT

A study on bio-economic appraisal of different land use systems in dry temperate north western Himalayas was carried out in different altitudinal gradients in Kinnaur district of Himachal Pradesh. Three altitudinal gradients were considered for the study viz; 1900-2170 m, 2170-2440 m and 2440-2710 m above msl. In each altitudinal gradient six land use systems i.e, agriculture, horticulture, agri-horticulture, agri-hort-silviculture, silvipastural and barren land which were common to all the three altitudinal levels were selected. In this study gross return, production cost, net profit and benefit cost ratio were estimated. Gross return was maximum (Rs 18,23,000) in agri-horticulture system, which was closely followed by the land use systems of horticulture, agri-horti-silviculture, silvi-pasture system, agriculture and barren land, respectively in the descending order. Irrespective of land use systems gross return increases with the increase in altitudinal levels. Production cost followed the order: agri-horticulture > horticulture > agri-horti-silviculture > agriculture > silvi-pasture > barren land, respectively. Maximum net profit was attained by agri-horticulture system (Rs, 13,10,000), which was closely followed by horticulture (Rs 11,65,852), only. Net returns as achieved in other land use systems *viz*., agriculture, silvi-pasture and barren land were quite low in comparison to fruit based land use systems. In altitudinal ranges, the net profit obtained increased appreciably from A_1 to A_3. A_3 altitudinal range had the highest net profit. Benefit-cost ratio was maximum (6.63) in the silvi-pasture based land use system, which was closely followed by the land use systems of barren land (4.73), horticulture (3.93), agri-horticulture (3.50) and agriculture (1.41), respectively, in the descending order.

Keywords:

agroforestry systems, altitude, benefit-cost ratio, dry temperate

INTRODUCTION

In subsistence agriculture on hill-slopes, there exists a complementary relationship among trees, crops and livestock, where trees and crops provide fodder and litter to livestock and in turn benefit from draft power and manure provided by animals. Several species of trees and shrubs grown on farm lands are important sources of fodder for livestock (Carson 1992; Yadav 1992). A major impact of agroforestry is on the increase of the farm's gross income over time. Indian farmers of Western Rajasthan were able to derive extra economic benefit through a combination of useful trees and shrub species (Saxena 1994). On hill slopes, with suitable biophysical conditions for growing trees and shrubs, agroforestry can contribute significantly to the improvements in household economic conditions, eventually enabling farmers to fulfill their food requirements (Thapa and Weber 1994). Agroforestry has provided opportunity for diversification of existing land use systems and beneficial environmental impacts and higher returns as compared to sole cropping system (Chaturvedi 1991). Like any other agricultural technology, the adoption of agroforestry practices depends on the potential economic benefits accruing to farmers. A variety of economic and policy issues such as profitability, household benefits, equity, sustainability, soil conservation, environmental services, markets for inputs and outputs, gender, and institutions (property rights, for example) influence the nature and magnitude of AFS adoption (Alavalapati and Nair 2001; Mercer and Hyde 1991). Agroforestry systems have proven their financial viability and attractiveness as important land use alternatives in various settings throughout the world (Garrett 1997).Agroforestry is practiced by small and marginal farms in the. However, research on the economic potential of agroforestry in the north-western Himalayan region of of Himachal Pradesh has received little attention. Against this background, the primary objective of this study is bio economic appraisal of agroforestry systems in dry temperate western Himalayas.

MATERIALS AND METHODS

The present study was carried out in Kinnaur district of Himachal Pradesh which lies in the dry temperate region of western Himalaya having an elevation, ranging from 100 meters to over 6000 meters above mean sea level. It lies in the altitude 31^{0}34'59" N and Longitude 78^{0}25'00". Kinnaur is one of the smallest districts in India by population (83, 950). The economy of the district is predominately agrarian and about 64 per cent of the population is dependent on agriculture and its applied activities for earning their livelihood. Kinnaur experiences a dry temperate climate due to high elevation, with long winters from October to May and short summers from June to September.

Some parts of Kinnaur are situated high in Himalayas, where vegetation is sparse and consists primarily of hardy grasses. Apline species such as juniper, pine, fir, cypress and Rhododendron can be found at elevations between 3,500 and 5,000 meters, primarily in middle Kinnaur. At lower altitudes, temperate climate trees are found, including oak, chestnut, maple, birch, alder, apple and apricot.

Tree crop combinations were Agriculture (T_1), Horticulture (T_2), Agri-horticulture (T_3), Agri-horti-silvicultural system (T_4), Silvi-pastoral system (T_5) and Barren land (T_6) with three altitudinal ranges viz., 1900 – 2170 m amsl (A_1), 2170-2240 m amsl (A_2), and 2440-2710 m amsl (A_3). The detail of each treatment is listed in Table 1.

The primary data were collected from 90 farmers of the area (30 farmers from each altitudinal range) in the year 2011-12. The data includes socioeconomic status of the farmers, inputs used (planting material, insecticides, pesticides, labour used for various activites, mechanical power, fertilizers etc.) and output of various crops and trees under different agroforestry systems.

Biological productivity was calculated considering the utilizable biomass of each functional unit of the system type. Production cost (variable costs) was calculated as per the prevailing rates of various inputs used. The gross returns were calculated on the basis of prevailing mandi (Agriculture Produce Marketing Committee) rates of the various crops in the study period. Net returns were calculated by deducting total costs incurred from gross returns. Benefit cost ratio (BCR) was calculated by dividing gross profits with production cost of the respective agroforestry systems.

RESULTS AND DISCUSSION

The data for gross returns, production cost, net profit and cost-benefit ratio had been presented in Table 2-4. The gross returns, total expenses, net profit which can be obtained from agroforestry land use systems as well as pure orchard at their respective altitudinal ranges were markedly higher

Table1: Different landuse systems used in the Kinnaur dist of Himachal Pradesh

Landuse systems	System units/altitudinal gradients		
	1900 - 2170 m	2170 – 2440 m	2440 – 2710 m
Agriculture (A)	Pea - Maize Wheat – Rajmash Barley - Rajmash	Peas – cabbage Wheat – Rajmash Barley - Rajmash	Wheat – Rajmash Wheat – Rajmash Barley - Rajmash
Horticulture (H)	Apple	Apple	Apple
Agri – horticulture (AH)	Apple + Peas - Maize Apple + Wheat - Rajmash Apple + Barley – Rajmash	Apple – Peas – Cabbage Apple + Wheat – Rajmash Apple + Barley - Rajmash	Apple + Wheat – Rajmash Apple + Wheat – Rajmash Apple + Barley - Rajmash
Agri - hort – silviculture (AHS)	Robinia + Apple – Pea + Maize Ailanthus altissima + Apple – Pea + Maize Salix tetraperma + Apple + Pea - Maize	Robinia + Apple + Pea – Cabbage Populus ciliata + Apple +Wheat – Rajmash Cedrus deodara + Apple + Barley – Rajmash	Cedrus deodara + Apple + Wheat – Rajmash Pinus gerardiana + Apple + Wheat – Rajmash Cedrus deodara + Apple + Barley - Rajmash
Silvi -pastoral (SP)	Pinus gerardiana + Grasses +Artemisia inbia +A. brevifolia	Pinus gerardiana + A. brevifolia + Grasses	Cedrus deodara + A. brevifolia +Lespedeiza + Grasses
Barren land (BL)	Artemisia inbia + Grasses A. inbia + Grasses Myrsine species + Grasses	Artemisia inbia + Grasses Artemisia inbia A. brevifolia + Grasses	Grasses +Lespedeiza gerardiana Grasses +Lespedeiza gerardiana Grasses +Lespedeiza gerardiana

Table 2: Gross returns from different landuse systems in the selected altitudinal gradient of the Kinnaur district of Himachal Pradesh (Rs ha^{-1} yr^{-1})

Land use systems (T)	Altitudinal ranges (A)			
	A 1 (1900-2170 m)	A 2 (2170-2440 m)	A 3 (2440-2710 m)	Mean
T 1 (Agriculture)	246100	332100	259300	279200
T 2 (Horticulture)	999000	1270000	2400000	1556000
T 3 (Agri -horticulture)	1220000	1616000	2633000	1823000
T 4 (Agri -horti-silviculture)	501700	631600	1396000	843000
T 5 (Silvi -pasture)	647000	471000	523400	547100
T 6 (Barren land)	7500	10000	13000	10170
Mean	603500	721000	1204000	

	SE(d)	$CD_{0.05}$
T	37338	75880
A	26402	53656
T x A	45730	64670

Table 3: Production cost (variable costs) of different landuse systems in the selected altitudinal gradient of the Kinnaur district of Himachal Pradesh (Rs ha^{-1} yr^{-1})

Land use systems (T)	Altitudinal ranges (A)			
	A 1 (1900-2170 m)	A 2 (2170-2440 m)	A 3 (2440-2710 m)	Mean
T 1 (Agriculture)	194400	209300	180000	194600
T 2 (Horticulture)	272600	312400	589400	391400
T 3 (Agri -horticulture)	393900	447100	697800	512900
T 4 (Agri -horti-silviculture)	145900	345500	575700	355700
T 5 (Silvi -pasture)	97200	95530	99100	97280
T 6 (Barren land)	1833	2500	2500	2278
Mean	184300	235400	357416	

	SE(d)	$CD_{0.05}$
T	57794	117450
A	40866	83051
T x A	70780	100100

Table 4: Net profit of different landuse systems in the selected altitudinal gradient of the Kinnaur district of Himachal Pradesh (Rs ha^{-1} yr^{-1})

Land use systems (T)	Altitudinal ranges (A)			
	A 1 (1900 -2170 m)	A 2 (2170 -2440 m)	A 3 (2440 -2710 m)	Mean
T 1 (Agriculture)	51660	122800	79290	84580
T 2 (Horticulture)	726400	957600	1811000	1165000
T 3 (Agri -horticulture)	826500	1169000	1936000	1310000
T 4 (Agri -horti-silviculture)	355800	286000	820300	487400
T 5 (Silvi -pasture)	549800	375500	424300	449900
T 6 (Barren land)	5667	7500	10500	7889
Mean	419300	486400	846800	

	SE(d)	**$CD_{0.05}$**
T	33281	67635
A	23533	47825
T x A	40760	57640

Table 5: Benefit cost ratio (BCR) of different landuse systems in the selected altitudinal gradient of the Kinnaur district of Himachal Pradesh

Land use systems (T)	Altitudinal ranges (A)			
	A 1 (1900 -2170 m)	A 2 (2170 -2440 m)	A 3 (2440 -2710 m)	Mean
T 1 (Agriculture)	1.27	1.53	1.44	1.41
T 2 (Horticulture)	3.67	4.06	4.07	3.93
T 3 (Agri -horticulture)	3.10	3.61	3.78	3.50
T 4 (Agri -horti-silviculture)	3.25	1.80	2.44	2.50
T 5 (Silvi -pasture)	6.66	4.94	5.28	6.63
T 6 (Barren land)	4.83	4.07	5.26	4.73
Mean	3.80	3.33	3.72	

	SE(d)	**$CD_{0.05}$**
T	33281	67635
A	23533	47825
T x A	40760	57640

than pure agriculture. Maximum gross returns (Rs 18, 23,000 $ha^{-1}yr^{-1}$) as well as net profit (Rs 1,31,00,00 $ha^{-1}yr^{-1}$) were in the agri-horticulture land use systems. Whereas, benefit-cost ratio was maximum (6.63) in silvi-pasture and least in agriculture (Table 5). This is because of the fact that these systems hardly require any input but gives good returns because of valuable produce i.e. *neoza* (chilgoza pine) which fetches high market price.

From the above results it is clear that the benefits were higher in the land use systems involving apple fruit trees in association with the agriculture and vegetable crops, viz., peas, rajmash, cabbage, wheat, barley etc. The higher per unit market price of apple and vegetable crops, particularly peas and *rajmash* is because of favourable climatic condition which makes them highly beneficial to the region. Higher profitability of the fruit based agroforestry systems have also been reported in the literature, elsewhere. Sood (1999) conducted an experiment studying tree crop interaction in which he reported that total cost incurred as well as net returns were higher agri-horticulture systems as compared to sole crops. Kumar (1999) reported that total costs, gross returns and net profit were higher from combination of pomegranate with soya bean, while least from soyabeans. Koul and Panwar, 2012 had also reported agroforestry systems as best options for bioeconomics as carbon credits can also play a role in income generation in addition to providing diversified out put in such integrated systems.

Tomar and Bhatt (2004), recorded maximum net monetary benefit per hectare when peach was intercropped with rice (Rs 40,4004), followed by guava (Rs 27, 087) Assam lemon (Rs 20, 991), respectively as compared to sole cropping. Under apple trees in ginger intercropping systems (Fan-wie et al. 2000) recorded 3 times more income from the system as compared with that of the apple orchard without intercropping. Singh (2010) also found apple with agri-horticulture system in temperate ecosystem of Himachal's Himalayas highly paying in comparison to monoculture.

Tables 2-4 also showed that the gross returns, total expenses as well as net profit increases with increasing altitudinal ranges. Highest altitudinal range i.e. 2440-2710m amsl displayed almost two times more net profit than $A_1$and A_2 altitudinal range. These altitudinal ranges viz; 1900-2170m, 2170-2440m and 2440-2710m amsl were framed in such a way that they represent 1^0shifts in the temperature. Therefore in future if the temperature of the region increases then it is bound to have an impact on the socio-economy of the people. Therefore, we need to plan and adopt suitable measures in order to avoid any financial losses to the people.

CONCLUSIONS

Maximum net profit (13,10,000 Rs ha^{-1} yr^{-1}) was calculated to be in agri-horticulture system which was followed by horticulture, agri-horti-silviculture, silvi-pasture, agriculture and barren land, respectively in the descending order. In the altitudinal ranges the net-profit enhanced with increasing altitudinal ranges. Silvi-pasture was found to have the highest benefit cost ration in the all the three altitudinal ranges i.e. 1900-2170 m amsl (6.66), 2170-2240 m amsl (4.94) and 2440-2710 m amsl (5.29).

REFERENCES

Alavalapati JRRand Nair PKR 2001 Socioeconomics and institutional perspectives ofAgroforestry. In:*World Forests, Society and Environment: Marketsand Policies*. Palo M and UusivuoriJ. (eds). Dordrecht, The Netherlands: Kluwer Academic Publishers. pp 71-81

Carson Brian 1992*The land, the farmer and the future: asoil fertility management strategies for Nepal*. Nepal: ICIMOD.

ChaturvediAN 1991 Agroforestry in India with particular reference to economic factors. In: *Agroforestry in Asia and Pacific*. Mellink W, Rao Y S and Mc Dicken K G. (eds). pp. 278-287.

Fan Wei, Zhang Jinsong, Yang Yisong and Wang Lian 2000 Preliminary study on an apple tree and ginger intercropping system in the limestone hilly regions of the Taihang Mountains. *Forest Research, Beijing* **13(5):** 543-546.

Garrett HEG 1997 *Agroforestry: an integrated* *land-use management system for production andfarmland conservation.* Washington: United States Department of Agriculture Soil Conservation Service.

Koul DN and Panwar P 2012 Opting different land use for carbon buildup in soils and their bioeconomics in humid subtropics of West Bengal, India *Ann. For. Res.* **55(2)**: 253-264.

Kumar M 1996 Bio-economic appraisal of agroforestry land use systems. M.Sc. Thesis. Dr.Y.S. Parmar University of Horticulture and forestry, Nauni, Solan (H.P.) India.

Mercer DEand Hyde WF 1991 The economics of agroforestry. In:*Social Science Applications in Asian Agroforestry*.Burch Jr.W R and Parker J K(eds.). New Delhi, India: Oxford &IBH Publishing. pp. 111-143

Saxena SK 1994 Traditional agroforestry systems in agroecologicalzones of western Rajasthan. *Annals of Arid Zone* **33**(4): 279-285

Singh VP 2010 Addressing the Challenges of Climate Change for Securing Sustainable Livelihoods in India. IFAD Investment Strategy for India. (*in*) *COSOP Document for India*, at IFAD, Rome, p 27.

Sood R 1999 Tree crop interaction studies in agri-horticulture system. M.Sc. Thesis, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). India. 81p.

Thapa GB and Karl EW 1994 Managing mountain watersheds in Nepal: issues and policies Water Resourc. Dev **10 (4):**475–495

Tomar JMS and Bhatt BP 2004 Studies on horti-agricultural system in a mid altitude of Meghalaya. *Indian Journal of Agroforestry* **6(2):** 35-39.

Yadav Y 1992 Farming-forestry-livestock linkages: a component of mountain farmers' strategies. In: *Sustainable Mountain Agriculture: perspectives and issues* Vol. 1. Jodha NS, Banskota M and Partap T (eds). New Delhi: Oxford and IBH Publishing Co Ltd.