The Pharma Innovation Journal 2022; 11(12): 832-836

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 832-836

www.thepharmajournal.com
Received: 15-09-2022
Accepted: 19-10-2022

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Resource use efficiency of selected agro-forestry systems in Kashmir valley

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Abstract
The study was carried on the Resource use Efficiency of Agroforestry systems at District Bandipora and Ganderbal. From each district two Blocks were selected and out of these four blocks fifteen respondents/ households were selected taking the total number up to 240. Four agroforestry systems were prevalent in the study area i,e Horti-agricultural system, Agri-Horti-Silvicultural system, Silvi-pastoral system and Boundary plantation. The study investigate that in case of Horti-agricultural system in district Bandipora all the variables were found underused and in district ganderbal expect unskilled labour which was found overused all other variables were underused. Similarly, in Horti-agri-silvicultural system in both districts *viz*. Bandipora and Ganderbal, unskilled labour, skilled labour and plant protectors were found underused whereas plant material and manure/fertilizers were found overused. In case of Boundary-Plantation system except unskilled labour all other variables were found underused and in district Ganderbal all the variables were found underused. In case of Silvi-pastoral system both the district of Bandipora and Ganderbal unskilled labour and plant material were found underused whereas manure/fertilizer and skilled labour were found overused respectively.

Keywords: Resource, efficiency, agroforestry, Bandipora, Ganderbal, horti-agricultural, horti-agri-silvicultural, silvi-pastoral

Introduction
Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. Trees produce a wide range of useful and marketable products from fruits/nuts, medicines, wood products, etc. This intentional combination of agriculture and forestry has multiple benefits, such as greatly enhanced yields from staple food crops, enhanced farmer livelihoods from income generation, increased biodiversity, improved soil structure and health, reduced erosion, and carbon sequestration. In an agroforestry system competitive interaction develops between trees and crops for the limited resources, above ground for light and below ground for soil, water and nutrients. Asymmetry in resource utilization in agroforestry is due to difference in establishment timing of trees and crops Bhat *et al*., 2003 [1]. Evapo transpiration from understory plants may be decreased by the tree shadow, resulting in a possible increase in soil water content relative to open pastures Joffre and Rambal, 1993 [2]. Gupta *et al*. 2009 [3] carried out research in a poplar (Populus deltoids.) based AF plantation and reported that average soil organic carbon increased from 0.36% in mono crop to 0.66% in AF soils (2.9-4.8 Mg ha^{-1} higher) and this was found to increase with tree age. Studies of litter enrichment services from Ficus trees (Ficus benghalensis) in rain fed AF systems in Karnataka showed that the Ficus litter could deliver approximately 20 percent of the necessary phosphorus, 77 percent of the necessary nitrogen and 67 percent of the needed potassium Dhanya *et al*., 2013 [4]. The effects of five multi-purpose tree species (MPTs) on soil in AF farms located in the north-eastern Himalayan region of India were studied by Saha *et al*. 2010 and found that all soil hydro-physical characteristics were greatly improved. It has also been shown that agroforestry systems can restore contaminated land and reduce soil salinization and acidification (Murthy *et al*., 2013) [6]. One of the most viable options for managing land and soil resources is the eco-restoration and subsistence of soil resources through AF Dhyani and Chauhan, 1995 [7]. It has been shown that AF vegetative buffers minimise non-point source contamination from row crop farming. Trees with deep roots provide a safety net of sorts by filtering back into the system surplus nutrients and enhancing the quality of nutrient usage. The use of energy from agroforestry systems would decrease reliance on fossil fuels and fuel wood forests.

Data and Methodology

Both secondary and primary data are used to support the investigation. The secondary information on the area, output, and yield of agroforestry systems was gathered from a variety of published sources, statistical digests, periodicals, books, and journals. Primary information on the various facets of the agroforestry system was gathered from the chosen farmers. Stage 1 of data gathering involved choosing two districts from Jammu and Kashmir. Bandipora and Ganderbal were purposefully chosen since they were closer to the researcher's home and provided him with more access to the areas. In the second stage of block selection, the two districts' blocks were listed and ordered according to the area covered by the A.F. Two blocks from each district—Aloosa, Arin from Bandipora and Kangan, Gund from Ganderbal—were chosen based on the maximum area covered by the A.F. The villages in each block were listed in the third stage, and four villages from each block were randomly chosen through a lottery. In the fourth stage, the selection of households, a total of 60HH from each block were selected randomly for detailed analysis, bringing the sample size to 240 households.

Analytical tools

Cobb-douglas production function

$$Q = f(X_1, X_2, X_3, X_4, X_{5+}\varepsilon)$$

Where,

Y = Production (Rs/ha)

X_1 = Cost incurred on Unskilled Labour (Rs/ha)

X_2 = Cost incurred on Plant material (Rs/ha)

X_3 = Cost incurred on Manure/fertilizers (Rs/ha)

X_4 = Cost incurred on Skilled labour (Rs/ha)

X_5 = Cost incurred on Plant Protectors (Rs/ha)

ε = Error term

Result and Discussion

Table 1: Estimation of resource use efficiency of Horti-agriculture system in district Bandipora using Cobb–Douglas production function

Variables	Coefficients (Pv)	MVP	MFC Case1	MFC Case2	Case 1 r =MVP/MFC	Case2 r = MVP/MFC	Efficiency Level
Unskilled Labour	0.225 (0.843)	1345.800	1	600 (Rs/day)	1345.800	2.243	Underused
Plant material	0.894* (0.023)	1438.400	1	100 (Rs/plant)	1438.400	14.384	Underused
Manure/fertilizer	1.927* (0.017)	2112.000	1	200 (Rs/kg)	2112.000	10.56	Underused
Skilled Labour	5.026 (0.593)	65244.600	1	300 (Rs/day)	65244.600	217.482	Underused
Plant protectors	0.945*(-0.008)	2651.500	1	500 (Rs/Lt)	2651.500	5.303	Underused
R^2	0.78						
Adjusted R^2	0.74						

Note: *Significant at 5 percent level,
PV Figure in parenthesis represents probability value

Table 2: Estimation of resource use efficiency of Horti-agriculture system in district Ganderbal using Cobb–Douglas production function

Variables	Coefficients (PV)	MVP	MFC Case1	MFC Case2	Case 1 r = MVP/MFC	Case2 r = MVP/MFC	Efficiency Level
Unskilled Labour	-1.243* (0.021)	-9668.7	1	600 (Rs/day)	-9668.737	-16.114	Overused
Plant material	5.231* (0.003)	10389.5	1	100 (Rs/plant)	10389.5	103.895	Underused
Manure/fertilizer	0.847 (0.139)	941.600	1	200 (Rs/kg)	941.600	4.708	Underused
Skilled Labour	13.528* (0.018)	123412.707	1	300 (Rs/day)	123412.707	411.375	Underused
Plant protectors	0.945* (-0.009)	2468.130	1	500 (Rs/Lt)	2468.130	4.936	Underused
R^2	0.75						
Adjusted R^2	0.71						

Note: *Significant at 5 percent level,
PV Figure in parenthesis represents probability value

Estimation of resource use efficiency in district Bandipora

The estimated resource-use efficiency in Agroforestry systems is registered in Table. R^2 was 0.78 indicating that 78 percent of the variations in the output of Agroforestry system were explained by the explanatory variables included in the model. It is evident from Table that except Labour for unskilled activities (X1) and Labour for skilled activities (X4), all variables included in the model were positive and significant. Hence, increase in the use of inputs such as Labour for unskilled activities (X1), plant material (X2), Manure/fertilizer (X3), Labour for skilled activities (X4) and Plant protectors (X5) would increase the yield of Agroforestry systems by 0.22 percent, 0.89 percent, 1.92 percent, 5.02 percent and 0.94 percent, respectively.

Estimation of resource use efficiency in district Ganderbal

The estimated resource-use efficiency in Agroforestry system production is documented in Table. The R^2 value was 0.75 which indicates that 75 percent of the variations in the output were explained by the explanatory variables included in the model. It is evident from Table that except, Manure/fertilizer (X3) all variables included in the model were positive and significant. Hence, increase in the use of inputs such as plant material (X2), Manure/fertilizer (X3), Labour for skilled activities (X4) and Plant protectors (X5) would increase the yield of Agroforestry systems by 5.23 percent, 0.84 percent, 13.52 percent and 0.94 percent, respectively, while as expenditure on Labour for unskilled activities (X1), would reduce the returns by -1.24 percent, thereby indicating overuse of this variable, which needs relocation of funds from this input to other inputs.

Table 3: Estimation of resource use efficiency of Agri-horti-silvicultural system in district Bandipora using Cobb–Douglas production function

Variables	Coefficients (PV)	MVP	MFC Case1	MFC Case2	Case 1 R=MVP/MFC	Case2 r=MVP/MFC	Efficiency Level
Unskilled Labour	0.966* (-0.006)	4282.454	1	600 (Rs/day)	4282.454	7.13	Underused
plant material	-0.960* (0.005)	-2788.970	1	150 (Rs/plant)	-2788.970	-18.59	Overused
Manure/fertilizer	-0.975 (0.068)	-7696.60	1	200 (Rs/kg)	-7696.60	-38.48	Overused
Skilled Labour	0.906* (0.001)	8154.27	1	300 (Rs/day)	8154.27	27.18	Underused
Plant protectors	0.468* (0.001)	926.84	1	500 (Rs/Lt)	926.84	1.85	Underused
R^2	0.82						
Adjusted R^2	0.77						

Note: *Significant at 5 percent level,
PV Figure in parenthesis represents probability value

Table 4: Estimation of resource use efficiency of Agri-horti-silvicultural system in district Ganderbal using Cobb–Douglas production function

Variables	Coefficients (PV)	MVP	MFC Case1	MFC Case2	Case 1 R = MVP/MFC	Case2 r = MVP/MFC	Efficiency Level
Unskilled Labour	1.045* (0.004)	4479.300	1	600 (Rs/day)	4479.300	40.79	Underused
plant material	-0.940* (0.023)	-2530.880	1	150 (Rs/plant)	-2530.880	-16.872	Overused
Manure/fertilizer	-1.641 (1.175)	-13331.06	1	200 (Rs/kg)	-13331.06	-66.65	Overused
Skilled Labour	1.012* (0.010)	7979.56	1	300 (Rs/day)	7979.56	26.59	Underused
Plant protectors	0.427* (0.005)	844.248	1	500 (Rs/Lt)	844.24	1.68	Underused
R^2	0.74						
Adjusted R^2	0.705						

Note: *Significant at 5 percent level
PV Figure in parenthesis represents probability value

Estimation of resource use efficiency in district Bandipora

The estimated resource-use efficiency in Agroforestry system production is furnished in Table. The R^2 value was 0.82 which indicates that 82 percent of the variations in Agroforestry system yield were influenced by the explanatory variables included in the model. It is evident from Table that except, Manure/fertilizer (X3) all variables included in the model were positive and significant. Hence, increase in the use of inputs such as Labour for unskilled activities (X1), Labour for skilled activities (X4) and Plant protectors (X5) would increase the yield of Agroforestry systems by 0.96 percent0.90 percent and 0.46 percent, respectively, while as increase in the use of plant material (X2), Manure/fertilizer (X3) would reduce the output by -0.96 and -0.97 percent, respectively.

Estimation of resource use efficiency in district Ganderbal

The estimated resource-use efficiency in Agroforestry system production is furnished in Table. The R^2 value was 0.74 which indicates that 74 percent of the variations in the output of the system were explained by the explanatory variables included in the model. It is evident from Table that except, plant material (X2) and Manure/fertilizer (X3) all variables included in the model were positive and significant. Hence, increase in the use of inputs such as Labour for unskilled activities (X1), Labour for skilled activities (X4) and Plant protectors (X5) would increase the output of the system by 1.04 percent, 1.01 percent and 0.42 percent, respectively, as against plant material (X2) and Manure/fertilizer (X3),) where the additional investment would reduce the output by 0.94percent and 1.64 percent respectively.

Table 5: Estimation of resource use efficiency of Boundary plantation in district Bandipora using Cobb–Douglas production function

Variables	Coefficients (PV)	MVP	MFC Case1	MFC Case2	Case 1 R = MVP/MFC	Case2 r = MVP/MFC	Efficiency level
Unskilled Labour	-1.260 (0.365)	-2584.950	1	600 (Rs/day)	-2584.950	-4.308	Overused
plant material	0.948 (0.295)	378.523	1	50 (Rs/plant)	378.523	7570.46	Underused
Manure/fertilizer	11.304* (0.046)	43700.146	1	100 (Rs/kg)	43700.146	437.340	Underused
Skilled Labour	4.649* (0.002)	19328.070	1	300 (Rs/day)	19328.070	64.426	Underused
Plant protectors	21.201* (0.007)	51261.095	1	200 (Rs/Lt)	51261.095	256.305	underused
R^2	0.77						
Adjusted R^2	0.700						

Note: *Significant at 5 percent level,
PV Figure in parenthesis represents probability value

Table 6: Estimation of resource use efficiency of Boundary plantation in district Ganderbal using Cobb–Douglas production function

Variables	Coefficients (PV)	MVP	MFC Case1	MFC Case2	Case 1 R = MVP/MFC	Case2 r = MVP/MFC	Efficiency Level
Unskilled Labour	1.926* (0.008)	4171.914	1	600 (Rs/day)	4171.914	6.953	underused
plant material	1.302 (0.290)	541.990	1	50 (Rs/plant)	541.990	10.83	Underused
Manure/fertilizer	5.080* (0.089)	15531.375	1	100 (Rs/kg)	15531.375	155.31	Underused
Skilled labour	1.374* (0.001)	4378.520	1	300 (Rs/day)	4378.520	14.595	Underused
Plant protectors	3.781 (0.15)	9006.493	1	200 (Rs/Lt)	9006.493	45.032	Underused
R^2	0.84						
Adjusted R^2	0.781						

Note: *Significant at 5 percent level,
PV Figure in parenthesis represents probability value

Estimation of resource use efficiency in district Bandipora
The estimated resource-use efficiency in BP Agroforestry system is reflected in Table. The R^2 value was 0.77 which indicates that 77 percent of the variations in the output of the system were influenced by the explanatory variables included in the model. It is evident from Table that except, Labour for unskilled activities (X1) all variables included in the model were positive and significant. Hence, increase in the use of inputs such as plant material (X2), Manure/fertilizer (X3), Labour for skilled activities (X4) and Plant protectors (X5) would increase the yield of Agroforestry systems, 0.94 percent, 11.30 percent, 4.64 percent and 21.20 percent, respectively, however, Labour for unskilled activities (X1) turned overused and therefore, would reduce output by 1.26 percent.

Estimation of resource use efficiency in district Ganderbal
The estimated resource-use efficiency of Boundary-plantation system of Agroforestry is documented in table above. The R^2 value was 0.84 which indicated that 84 percent of the variations in Agroforestry system are explained by the explanatory variables included in the model. It is evident from Table that except, plant material (X2) and Plant protectors (X5) all variables included in the model were positive and significant. Hence, increase in the use of inputs such as unskilled activities (X1), Manure/fertilizer (X3) and Labour for skilled activities (X4) would increase the yield of Agroforestry systems by 1.92 percent, 5.08 percent, 1.37 percent, respectively, however, plant material and plant protector turned non-significant and hence did not influence the output.

Table 7: Estimation of resource use efficiency of Silvi-pastoral system in district Bandipora using Cobb–Douglas production function

Variables	Coefficients (PV)	MVP	MFC Case1	MFC Case2	Case 1 R = MVP/MFC	Case2 r = MVP/MFC	Efficiency Level
Unskilled Labour	4.445 (0.002)	10423.49	1	600 (Rs/day)	10423.49	17.370	Underused
plant material	1.344* (-0.008)	242.470	1	50 (Rs/plant)	242.470	4.849	Underused
Manure/fertilizer	-7.809* (0.012)	-17251.86	1	50 (Rs/kg)	-17251.86	-345.02	Overused
Skilled labour	-0.713* (0.770)	-7625.98	1	200 (Rs/day)	-7625.98	-38.125	Overused
R^2	0.97						
Adjusted R^2	0.96						

Note: Significant at 5 percent level,
PV Figure in parenthesis represents probability value

Table 8: Estimation of resource use efficiency of Silvi-pastoral system in district Ganderbal using Cobb–Douglas production function

Variables	Coefficients (PV)	MVP	MFC Case1	MFC Case2	Case 1 R = MVP/MFC	Case2 r = MVP/MFC	Efficiency Level
Unskilled b Labour	-0.602 (0.094)	1618.111	1	600 (Rs/day)	10423.49	17.370	Underused
Plant material	1.971* (0.001)	380.663	1	50 (Rs/plant)	242.470	4.849	Underused
Manure/fertilizer	7.511* (0.023)	16539.29	1	50 (Rs/kg)	-17251.86	-345.02	Overused
Skilled labour	0.982 (0.579)	11114.510	1	200 (Rs/day)	-7625.98	-38.125	Overused
R^2	0.89						
Adjusted R^2	0.86						

Note: *Significant at 5 percent level
PV Figure in parenthesis represents probability value

Estimation of resource use efficiency in district Bandipora
The estimated resource-use efficiency in silvi-pastoral system is reflected in Table. The R^2 turned 0.97 thus indicating that 97 percent of the variations in the model was explained by the explanatory variables included in the model. The figure further reveal that plant protection only was positively significant indicating under use of the resource, while on unskilled labour turned non-significant so did not affect the production process either negatively or positively meaning that the input did not impact the output. However, the other two variables I,e. Manures and Fertilizers and skilled labour showed significantly over use of these resources would decrease the production output by 7.80 and 0.713 percent respectively.

Estimation of resource use efficiency in district Ganderbal
The estimated resource-use efficiency in Silvi-pastoral system production is furnished in Table. The variables included explained 89 percent of the variations in the production system. Out of the four variables included in the model two were positively significant (plant material, manures and fertilizers) while as the one (unskilled labour) and other skilled labour both were non – significant. However unskilled labour had negative sign and the skilled labour had a positive sign which would indicate same rest of under and over use, respectively.

Conclusions and policy implications
One of the most significant potential systems for ensuring nutritional value, food security, and eradicating poverty in JK is agroforestry. In the study sites, the majority of farmers lack access to better extension services and human capacity building trainings. From an economic perspective, efficient resource usage is crucial to raising output levels and maximising returns. The cost of some resources employed in the production process has to be reduced for optimal allocation, whilst the cost of other resources needs to be raised for optimal allocation. This highlights the need of having the right technical expertise for farmers to effectively utilise the resources already in place. The study's findings suggest that in order to optimise return, resources should be allocated carefully. The provision of effective technical information about good agroforestry methods should be a top priority for the government and other interested parties.

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