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Comparative Economics of Silvopasture, Hortipasture and Annual Crops on Marginal Agricultural Lands of Arid Zone of Rajasthan

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Abstract: An attempt was made to study the alternative cropping systems in arid zone of Rajasthan, in comparison to arable farming. The silvopasture based livestock grazing system (silvopastoral systems), hortipasture and arable farming were compared. The silvopastoral and hortipasture systems were more profitable than arable farming system at 12 and 20% discount rates. Sensitivity analysis, further, confirm the results. However, the silvopastoral system with sheep grazing at 20% discount rate is not viable in most cases. Under new economic policy and GATT agreement, the alternative farming system is considered to be more viable, which would not only improve the living standard of the region but also improve the ecological balance and sustainability of the arid zone of Rajasthan.

Key words: Alternative cropping systems, arable farming, silvopasture, hortipasture, sustainability.

The state of Rajasthan, the second largest state of India, covers an area of 3422 thousand square kilometres, and forms nearly 10.4% of the total geographical area of the country. Twelve districts of the state have been identified as hot arid areas. These districts comprise nearly 2074 thousand square kilometres area and constitute 62% of the total hot arid region of India (Kalla and Bhati, 1988). This region is characterised by low and erratic rainfall, large temperature variations, high evaporation, scarce vegetation, rodent infestation, absence of perennial rivers, etc. The soils of the region have high pH, salinity, poor organic matter and nitrogen, and ill-defined profile development. A state level land utilisation committee, which consisted of soil scientists and conservation experts, found that only 21% of these lands, scattered over different districts, fall under categories III and IV as per FAO (1976) landuse capability classification. The remaining 79% of the land is not suitable for cultivation on a sustained basis, i.e., these lands are classified as V, VI, VII and VIII land capability classes, suitable only for pasture development, wild life conservation and recreation purpose. The ground water generally is of poor quality and may not be suitable for crop production. Due to low rainfall, the soil moisture is available only for 30 to 60 days, while most of the crops require moisture for more than 100 days.

The low grazing capacity, coupled with increasing grazing pressure on natural resources, has threatened agricultural sustainability of the region. The problem has been further escalated due to shift of more marginal lands and grazing lands to intensive cultivation. This has resulted in not only low productivity of land/crops, but has also caused imbalances in these fragile ecosystems. The low productivity leads to high

cost of production and low returns from marginal lands (Reddy and Kanwar, 1985). The farmers from poor resource endowment in such situation can not expect higher returns from marginal lands.

Several alternatives have been suggested for better management of such lands. Some of the alternate landuse systems are silvopasture, hortipasture and agroforestry. An attempt was made to quantify the economically viable systems, which can conserve the resources for future use. The specific objectives of the study were the following:

- to estimate net annual returns from crop production under marginal lands;
- to estimate the net returns from grazing of different livestock enterprises under silvopasture and hortipasture systems; and
- to compare the above systems for economic viability, as well as for maintenance of sustainability.

Materials and Methods

The data on silvopasture, hortipasture and annual crops were collected from the studies conducted at CAZRI Research farm, Jodhpur. Options of grazing (sheep, goat and cattle) were considered separately. Pearl millet, legumes, oilseeds and cash crops were grown in a 6.8 ha plot, in the ratio of 40:30:15:15.

The discounted measures of various farming systems fail to take into consideration adequately the costs and benefits in different timings. However, by discounting technique, future cash flows can be reduced to the present worth estimation of benefits and costs to arrive at net-present-worth (NPW), benefit-cost ratio (B-CR), and annuity value (AV) (Gittinger, 1972) as under:

$$B\text{–}CR = \frac{\sum_{i=1}^{n} B_t/(1+r)^i}{\sum_{i=1}^{n} C_t/(1+r)^i}$$

$$NPW = \sum_{i=1}^{n} B_t/(1+r)^i - \sum_{i=1}^{n} C_t/(1+r)^i$$

$$AV = NPW/\sum_{i=1}^{n} 1/(1+r)^i$$

where,

B_t = Benefit in each year up to 'n'th year
C_t = Cost in each year up to 'n'th year
n = Number of years (for the present study, 15 years have been considered the project life)
r = Discounted (Interest) rate, i.e., 12 and 20% in this study.

Sensitivity analysis

This analysis shows how the value of the criteria changes with change in value of any variables in discounted cash flow. It may be expressed either as the absolute or per cent change in cash flow. The appropriate method is per cent change in cash flow (Little and Mirrless, 1977). An attempt has been made by increasing the variable cost and return by 10 and 20%.

All the criteria were calculated in the following three combinations of cost and return:

- Between return and increased costs.
- Between increased return and cost.
- Between increased return and increased cost.

Results and Discussion

Cropping systems

The total area allocated to different crops, variable costs, gross income and profit over variable cost are shown in Table 1. The highest variable cost was recorded in mung bean (Rs. 1710), followed by that in clusterbean (Rs. 1616) and the pearl millet (Rs. 1541), and was lowest in castor crop. The castor crop did not yield any return. The gross income, as well as profit over variable cost were higher in cash crop, followed by cowpea, mung bean and pearl millet. Cowpea and mung bean could be considered as cash crops due to their market value. Clusterbean has high market value, as it finds commercial use in "Gum" industry. In the present economic scenario, clusterbean should be cultivated on large scale. However, the actual area allocation is still much higher for pearl millet, since it is a staple food in rural areas.

Alternate landuse systems

Two alternat landuse systems namely, silvopasture with grazing facility to sheep, goat, and cattle, and hortipasture system, were tested. Each has unique importance in economy of arid zone of Rajasthan.

Silvopasture system: In this system, fodder-fuel tree *(A. tortilis)* was planted at 8 x 8 m spacings so that canopy of one tree could not overlap the canopy of the other tree in the long run. The inter-space of the trees was utilised for pasture development (sp. *C. ciliaris*). The basal area occupied by the trees was about 0.24 ha and remaining area of 0.74 ha was available for pasture development. The expenditure and returns from silvopasture system with sheep, goat and cattle grazing is presented in Table 2. The pasture was resown in the 10th year. During first two years, nearly 72% expenditure on various inputs was incurred. The remaining 28% expenditure occurred in the 10th and the 15th year of the project. In the first year, 60% expenditure was involved only on watering the tree plants, followed by seedling and labor charges. In the second year, nearly 86% expenditure was on watering of the tree plants.

In this system, the produce was available for grazing of sheep, goat and cattle. The returns from sheep included selling of lambs,

Table 1. Area allocation, cost and return from different crops in arid zone (Rs. ha^{-1}) (Average; 1990-96)

Crop	Area (ha)	Variable cost	Gross income	Profit over variable cost	Benefit cost ratio
Pearl millet (Pm)	2.65	1541	3090	1549	2.01
Pm + moth bean	0.50	1359	2625	1266	1.93
Pm + mung bean	0.50	1359	3100	1741	2.28
Clusterbean	0.75	1616	4956	3340	3.07
Mung bean	0.50	1710	3952	2242	2.31
Moth bean	0.50	1350	2830	1480	2.10
Cowpea	0.40	1370	4106	2736	3.00
Castor + moth bean	0.50	823	728	-95	0.88
Castor	0.50	478	–	-478	–
Average	6.80	1376	2966	1591	2.16

Table 2. Cost and returns in Rs. ha^{-1} (average of 10 ha) from silvopasture system with different livestock activities

Particulars	Year					
	1	2	3-9	10	11-14	15
Cost						
Tree (0-20 ha)						
Seedling	1250					
Pitting	500					
Transportation	250					
Watering	7000	7000				
Transplanting	125					
Pesticides	500	500				
Weeding	200	200				
Pasture (0.74 ha)						
Seed	300			300		
Field preparation	500			500		
Pesticides	250			250		
Labor charges	800			2100		5000
Total	11675	8100	–	3150	–	5000
Returns						
Sheep	700	1400	23180*	2270	17560*	55100
Goat	700	1400	27817*	2800	21450*	56220
Cattle	700	1400	58567*	6420	47190*	63630

wool and manure added to soil through urine and droppings. The returns from goats were through sale of milk, kids and addition of fertilisers through urine and droppings. Similarly, the returns from cattle grazing were through selling of milk, kids, and fertilisers added to soils through dung and urine.

Hortipasture systems: In this system, raising horticultural crop, viz., *Zizyphus mauritiana* cv. Gola, locally called *gola ber*, was considered as the main activity. The total number of plants per ha was 250. The spaces between *ber* plants was used for raising pasture of grass *C. ciliaris*. In this system, products (*ber* fruits as well as grass) were sold in the market. No grazing was permitted. The cost and return structure for hortipasture system is given in Table 3. The cost was more in the first year due to activities related to establishment of the system. From 6th year onwards, the cost per year was constant, except in the 10th year when the pasture was resown. The return from hortipasture system was obtained in the form of sale of *ber*, grasses, pasture seeds, *pala* (leaf fodder) and twigs. At the end of the project, returns were also available from wood by cutting *ber* plants. However, the maximum return per year (nearly 90%) was obtained only from sale of *ber* fruits.

Table 3. Cost and return from hortipasture system of alternate landuse systems (Rs. ha^{-1} average of 10 ha)

Particulars	Years								
	1	2	3	4	5	6-9	10	11-14	15
Horticultural crop (*Ber*)									
Digging of pits	500								
Manure + BHC	1500	2000	2000	2000*	2000	2000*	2000*	2000*	2000*
Cost of plant	1500	–	–	–	–	–	–	–	–
Transplanting	100	–	–	–	–	–	–	–	–
Irrigation	1000	–	–	–	–	–	–	–	–
Weeding	500	500	500	700*	700	700*	700*	700*	700*
Pruning	100	100	150	300*	300	300*	300	300*	300*
Plant protection	–	1000	1000	1000*	1000	1000*	1000	1000*	1000*
Harvesting	–	–	500	1000	1500	2000*	2000	2000*	2000*
Pasture									
Seed	300	–	–	–	–	–	300	–	–
Pesticides	500	–	–	–	–	–	500	–	–
Labor charges	2100	800	800	800	800	800*	2100	800*	800*
Total	8350	4400	4950	5800	6300	6800*	9150	6800*	6800*
Returns	270	940	10470	18715	23715	128740**	32790	132920**	58715

* Same amount increased in each year.

** Total of 6 to 9 and 11 to 14 years.

Comparative Economics

The B-CR, NPW and AV at 12 and 20% discount rates are given in Table 4. AV was the highest in hortipasture system, followed by silvopasture systems with cattle and goat grazing at 12 and 20% discount rate. The AV from arable farming system was less than in case of silvopasture system with sheep grazing at 12 and 20% discount rates.

The B-CR was maximum under hortipasture system, followed by silvopasture system, with cattle grazing. The criteria for adoption of any project is generally based on NPW, if more than one project is under study (Gittinger, 1972). In the present study, one of the alternative project/option was, arable farming. In such situation, the AV could be chosen as criteria for decision making. From Table 4, it was observed that AV of all the alternative landuse systems, except silvopasture system with sheep grazing was more profitable than arable farming. The AV of arable farming was higher due to favorable climatological conditions (normal monsoon). Otherwise, the value could be less. The silvopasture system with sheep grazing, was not affected by the low rainfall. If the monsoon failed for two consecutively years the AV of arable farming would even have much less than the AV of silvopasture system with sheep grazing. The silvopasture system with sheep grazing at 20% discount rate was nonviable.

Comparing the AV of individual crop with alternate landuse systems, it was observed that hortipasture and silvopasture with cattle grazing were more beneficial

Table 4. Comparative economics of different farming systems in arid zone of western Rajasthan

Particulars	Arable farming	Silvopasture (Life of project, 15 years)			Hortipastoral (Project life, 15 years)
		Sheep	Goat	Cattle	
Expenditure (Rs.)	1376	27875	27835	29575	102650
Total returns (Rs.)		100210	110390	177990	407275
Profit over expenditure (Rs.)	1591	72635	82815	150415	304625
B-CR at 12% discount rate	2.16	1.52	1.71	2.96	3.22
B-CR at 20% discount rate	2.16	0.93	1.05	1.89	2.72
NPW at 12% discount rate (Rs.)	1591	9608.59	13518.44	36715.20	98376.37
NPW at 20% discount rate (Rs.)	1591	-1068.83	952.28	14333.28	51592.95
AV at 12% discount rate (Rs.)	1591	1410.77	1931.97	5390.65	1443.96
AV at 20% discount rate (Rs.)		-228.60	203.67	3065.61	11034.74

than arable farming. Crops like clusterbean, mung bean and cowpea were superior to the silvopasture with sheep and goat grazing system. At 25% less rainfall than normal (330 mm), 30% less profit would be obtained. The AV of clusterbean, mung bean and cowpea would be Rs. 2338, Rs. 1569 and Rs. 1915, respectively. However, the returns from silvopasture and hortipasture systems will remain unaffected due to this level of rainfall. The clusterbean was still superior to silvopasture with sheep grazing. The overall AV (Rs. 1114) of arable farming indicated that the system was least suitable for the region.

The sensitivity analysis at different combinations of cost and return was worked out (Table 5). It revealed that silvopasture system with sheep grazing and at 20% discount rate increase in cost was nonviable. However, the silvopasture system with cattle grazing and hortipasture system at 12% and 20% discount rate were viable. The B-CR, NPW and AV were still higher in case of hortipasture system, followed by silvopasture system with cattle grazing.

Externalities

By adoption of alternative landuse systems, the soil fertility status may improve, which will ultimately increase the production level and value of land. The soil erosion will be reduced due to vegetation cover in the area. Since the activities related to silvopasture system involve the family or hired labor round the year, the employment opportunity in the region will also increase. Due to increase in the production of livestock based farming, the secondary sector, which is based on the livestock input, will also increase the employment opportunities. In the present economic scenario (or due to GATT agreement), farmers should follow farm activities that generate maximum returns. The adverse effect of failure of monsoon is less on alternate landuse systems and there will be less need to initiate any relief work.

If the intangible benefits of alternate landuse systems are also taken into account, the silvopasture system with grazing facility and hortipasture system will be more viable.

Table 5. Sensitivity analysis of different farming systems in arid zone of Rajasthan

Particulars	Silvopasture system with grazing of						Hortipasture		Arable farming
	Sheep		Goat		Cattle		12%	20%	
	12%	20%	12%	20%	12%	20%			
B-CR									
A	1.66	1.03	1.87	1.16	3.25	2.07	3.54	2.99	2.37
B	1.81	1.12	2.04	1.27	3.54	2.26	3.86	3.26	2.59
C	1.33	0.82	1.49	0.93	2.60	1.66	2.93	2.47	1.96
D	1.51	0.93	1.70	1.05	2.95	1.89	3.22	2.72	2.16
E	1.59	0.98	1.79	1.12	3.12	1.98	3.51	2.96	2.35
F	1.26	0.78	1.42	0.88	2.46	1.57	2.68	2.26	1.80
G	1.38	0.86	1.56	0.97	2.71	1.72	2.95	2.49	1.98
H	1.51	0.93	1.70	1.05	2.95	1.89	3.22	2.72	2.16
NPW (Rs.)									
A	12448.75	472.22	16357.72	2665.51	42266.14	17384.62	112645.62	59756.71	1887
B	15288.93	1953.29	19552.92	4378.48	47814.01	20434.05	126912.72	67918.92	2183
C	7018.99	-3305.51	10568.84	-1284.40	34125.60	14333.28	93945.85	48581.59	1452
D	9859.15	-1764.46	13768.12	428.83	39676.54	15147.94	108215.17	56745.35	1749
E	12699.33	-283.39	16963.22	2141.80	45224.41	18197.37	122482.20	64907.56	2045
F	5850.00	-4304.69	9399.85	-2283.58	32956.61	11097.42	89515.29	45572.18	1315
G	8690.16	-2763.64	12599.13	-570.35	38507.55	14148.76	103784.61	53740.97	1612
H	11530.34	-1282.57	15794.33	1142.62	44055.42	14198.19	118051.64	61903.15	1908
AV (Rs.)									
A	1827.77	101.00	2401.70	570.10	6205.66	3718.24	16539.03	12780.82	1887
B	2244.77	417.77	2870.83	936.47	7020.22	4370.45	18633.77	14526.56	2183
C	1030.55	-706.99	1551.75	-274.71	5010.44	3065.61	13793.61	10390.67	1452
D	1447.55	-377.38	2021.48	91.72	5825.45	3239.85	15888.53	12136.74	1749
E	1864.56	-60.61	2498.61	458.09	6640.00	3892.07	17983.26	13882.49	2045
F	858.92	-591.09	1849.85	-121.99	5653.81	3026.81	15238.02	11494.16	1612
G	1275.92	-591.09	1849.85	-121.99	5653.81	3026.15	15238.02	11494.16	1612
H	1692.92	-274.32	2318.98	244.38	6468.37	3036.72	17332.75	1323.90	1908

A = Cost constant return increased by 10%
B = Cost constant return increased by 20%
C = Cost increased by 10% return constant
E = Cost increased by 10% return increased by 20%
F = Cost increased by 20% return constant
G = Cost increased by 20% return increased by 10%

Sustainability

The soil characteristics of the region are more suitable for livestock farming. The continuous use of such land for cropping may lead to decline in land productivity, and further increase unit cost of production and decline in income (Reddy and Kanwar, 1985). Under irrigated conditions, these soils

gave very low yields and increased the unit cost of production (Gajja *et al.*, 1996). Such lands are prone to salinity and water-logging which lead to further decline in yield and ultimately such land go out of cultivation. On the other hand, the alternate landuse systems for such soils are more suitable for pasture, horticulture crops, etc., and do not have any negative effect. Such systems will increase or maintain the resource productivity and conserve the resource for sustainable use.

Conclusion

Alternate landuse systems are more profitable than arable farming in this region. The return from hortipasture system is the highest. Due to marketing conditions and bluebull problems, the silvopasture system is also beneficial. Adoption of this system will improve the land productivity of the region and living standard, and will generate additional employment. It is suggested that farmers should be encouraged to adopt the silvopasture system with cattle grazing and Government should provide assured market facility. This system is more ecofriendly and sustainable in the region.

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