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Research Article

RESOURCE USE EFFICIENCY OF LIVESTOCK-BASED FARMING SYSTEMS: A COMPARATIVE STUDY BETWEEN SALINE AND NORMAL AREAS OF WEST BENGAL

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ABSTRACT

Salinity has deleterious effects on both crops and livestock. The present study evaluated the impact of salinity on livestock-based farming systems by comparing the economics of it on in saline and normal areas of West Bengal. The study also identified the factors affecting production function and resource use efficiency of different livestock-based farming systems. This will help the policy makers and farmers to adapt to this natural hazard. In saline area, S2 (1.216) and S3 (1.355) had increasing return to sale. In case of S2 farming system, both concentrate and veterinary services and for S3 concentrate, veterinary services and seed was using efficiently. Based on both resource use efficiency and return to scale, S2 should be recommended for landless farmers and S3 for land holders. In normal areas, N1 (1.4045) farming system showed increasing return to scale and also using fodder, veterinary services and fertilizer efficiently. Based on both resource use efficiency and return to scale N1 farming system should be recommended for the farmers in normal areas.

Keywords: Cobb-Douglas production function, Livestock-based farming systems, MVP to MFC ratio, Normal areas, Return to Scale, Saline areas

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Saline soil is expanding step by step and making a gigantic deal for the farmers with their land (Wongsomsak, 1986). Agricultural potential is decreased because of salinity issues (Ladeiro, 2012). Worldwide 20% of total cultivated land and 33% of irrigatedagricultural land are impacted by high salinity (Shrivastava and Kumar, 2015). In India, degraded land spread over around 147 million ha, out of which 23 million ha is debased because of saltiness/alkalinity/acidification which is the subsequent significant reason for soil degradation after water erosion (94 million ha) (Kumar and Sharma, 2020). Rice yield, sterility of spikelet and thousand-grain weight in the coastal area are seriously stressed by soil salinity which is liable for around 20 per cent yield decrease (Clermont *et al.*, 2010). There is a deficiency of fodder crops in the coastal saline regions because of salinity, this lack decreases the milk yield of bovines (Wistrand, 2003). The usage of salinity-affected fodder crops causes animals in saline areas to develop skin ailments, liver flukes, loose bowels, weight loss, and immune system deterioration (Alam *et al.*, 2017). Pregnant women in the coastal region experience the ill effects of gestational hypertension higher than the pregnant women in the non-beach front region because of utilization of salinity affected agricultural products (Khan *et al.*, 2008; WHO, 2003).

The Indo Gangetic Plains (IGP) are well known to provide nearly 50% of the total food consumption to feed 40% of the country's population (Pal *et al.*, 2009). The IGP fields are agronomically the most productive area of the nation and possess of almost 36% of the bovine population of the country (Singh *et al.*, 2005). Among the livestock sector, the bovine sector alone contributes to the tune of ₹ 235 billion to the IGP economy (Singh *et al.*, 2005). Every year in India, approximately 10% of the extra land becomes salinized, and by 2050, nearly half of all arable land will be contaminated by salt (Kumar and Sharma, 2020). Salinity increases in the area beneath the Indo-Gangetic plains will jeopardise our country's food security. Out of the absolute saline regions in the IGP districts (5,59,719 ha), 78.84% region (4,41,272 ha) is under West Bengal (Mandal *et al.*, 2010). The Coastal saline zone experiences both soil and water salinity and a lack of milk and dairy cattle was likewise seen in the coastal saline regions (Wistrand, 2003). Hence, the West Bengal state considered an ideal location for a comparative study of livestock-based farming systems in saline and normal environments.

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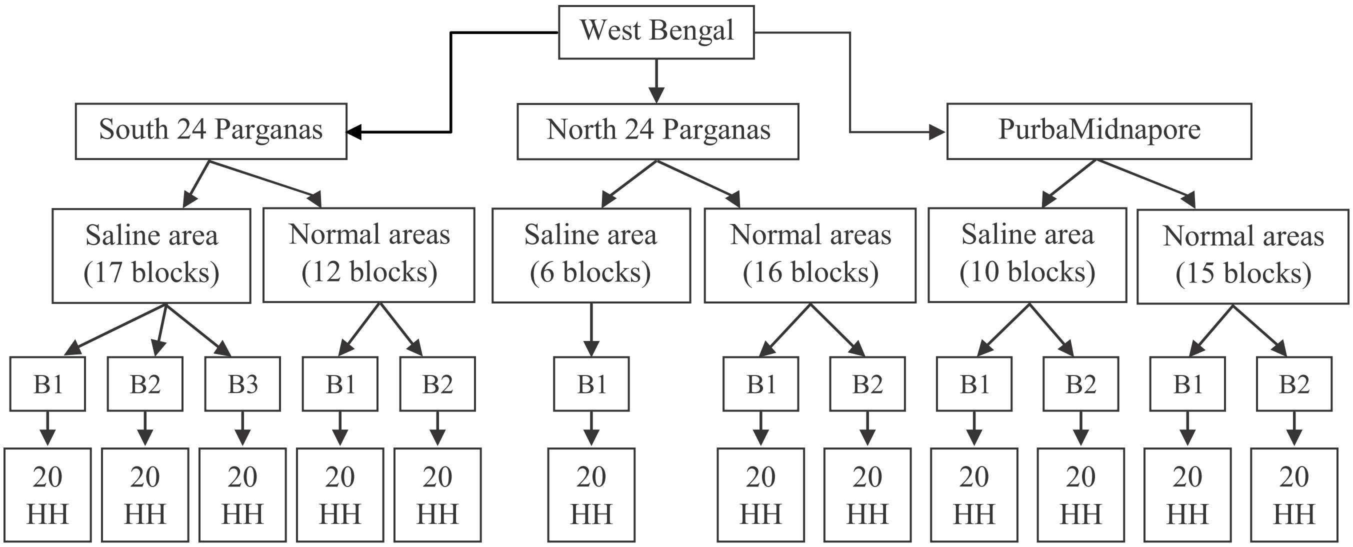
MATERIALS AND METHODS

Sampling plan: The major part of the coastal saline areas in West Bengal is in the Sundarban area of districts South 24 Parganas and parts of North 24 Parganas and Purba Midnapore (Bandyopadhyay *et al.*, 2003).

Within the selected districts, 17 blocks of South 24 Parganas, 6 blocks of North 24 Parganas and 10 blocks of Purba Midnapore is having saline areas. The rest of the blocks i.e., 12 blocks of South 24 Parganas, 16 blocks of North 24 Parganas and 15 blocks of Purba Midnapore are considered as normal areas for the comparison of livestock-based farming systems in saline and normal areas (GoW, 2018). For normal areas, randomly selected



blocks were Mograhat I and Mograhat II from South 24 Parganas; Barasat I and Bongaon from North 24 Parganas; Bhagwanpur I and Bhagwanpur II from Purba Midnapore. About 20 households from each block were selected based on random sampling. Total sample size was 240 households, 120 households from saline and another 120 households from normal areas. Primary data were collected on various aspects of livestock and crop enterprises from selected households for the year 2019-2020, through personal interview method from the door-steps of the respondents by using structured interview schedule. Farmers who were having 50% or more income from livestock were only considered as respondents for the present study.

Identification of different types of livestock-based farming systems was done based on the highest income contribution from livestock enterprises. For example; if the highest share of income earned by a household from livestock enterprises is through sheep rearing, then the system will be named sheep-based farming system and so on.

Resource use efficiency helps to determine the extent to which the important resources explain the variability in the gross return of the farming systems and also to determine whether the resources are used optimally in these farming systems. The Cobb-Douglas production function was used to study the resource use efficiency of different farming systems.

Heady and Dillon (1961) indicated the Cobb-Douglas production function is the best of all possible algebraic forms in the farm-firm analysis as it provides: (a) Comparison, (b) Adequate fit, (c) Computational feasibility and (d) Sufficient degrees of freedom.

Various studies are available on the Cobb-Douglas production function for analyzing resource use efficiency and return to scale (Wadear and Kiresur, 2003; Pandian *et al.*, 2013; Das, 2004; Mondal, 2009; Pattihal, 2015; Deshetti and Teggi, 2016; Bidari, 2014; Singh *et al.*, 2018, Hamsa *et al.*, 2017).

Cobb-Douglas production function

$$Y = aX_1^{b1} X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} e^{u} \text{..........(1)}$$

The Cobb-Douglas production function was converted into log-linear form and parameters (coefficients) were estimated by employing the Ordinary Least Square technique (OLS) as given below.

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + b_8 \log X_8 + u \text{..........(2)}$$

Where,

Y = Gross returns (₹/farm)

a = Intercept

X_1 =Seed cost (₹/acre)

X_2 =FYM and fertilizer cost (₹)

X_3 = Labour cost (₹)

X_4 = Green and dry fodder cost (₹)

X_5 =Cost of concentrates (₹)

X_6 =Cost of veterinary services (₹)

u = Random error term

b_i = Output elasticity of respective factor inputs, i =1, 2....6

Gross return of a particular farming system was calculated by adding the gross return of different enterprises/components under that farming system. Gross return for each enterprise was calculated by multiplying the quantity of livestock product produced with its prevailing market price. Area-wise the market price was different.

Returns to scale: The return to scale was estimated directly by getting the sum of 'b_i' coefficients. The returns will be increasing, constant or diminishing based on whether the value of summation of 'b_i' is greater, equal or less than unity, respectively.

Resource use efficiency: The ratio of the Marginal Value Product (MVP) and Marginal Factor Cost (MFC) of individual resources was used to judge the allocative efficiencies. The computed MVP was compared with the MFC or opportunity cost of the resource to draw inferences. As regards the resource use efficiency, whenever $MVP_{xi} > MFC_{xi}$ there is underutilization of resource X_i. $MVP_{xi} < MFC_{xi}$ there is overutilization of resource X_i. $MVP_{xi} = MFC_{xi}$ there is optimum utilization of resource X_i.

The MVP was calculated at the geometric mean levels of the variables using the formula

MVP of X_i^{th} resource = b_i*Y/X_i

Where,

Y = geometric mean of gross returns for identified respective farming systems

X_i = geometric mean of the i^{th} explanatory variable

b_i = regression coefficient i.e., elasticity of production of i^{th} explanatory variable

This analysis was carried out to identify the possibilities of increasing the gross return under a given farm situation.

The marginal fixed cost of different inputs was considered as one, since those inputs were measured in value terms in regression analysis.

RESULTS AND DISCUSSION

The farming systems identified in saline and normal areas of the study area in West Bengal are presented in Table 1.

Table 1. Identified farming systems in the study area

Code	Type of farming systems identified
Farming Systems in Saline Areas	
S1	Sheep+ Poultry
S2	Goat+ Poultry
S3	Cattle+ Goat+ Crop+ Fish
S4	Cattle+ Poultry+ Crop+ Fish
Farming Systems in Normal Areas	
N1	Cattle+ Goat+ Poultry+ Crop
N2	Cattle+ Goat+ Crop
N3	Cattle+ Poultry+ Crop

Economic optimum takes place where Marginal Value Product (MVP) equal to Marginal Factor Cost (MFC). Any deviation of MVP of i^{th} input from its unit price (or MFC) is termed as resource use inefficiency. The marginal factor cost (MFC) was considered as one, since those inputs have been measured in value terms in regression analysis.

The elasticity of concentrate cost (0.8470) was positive and significant at 1 per cent level in S1 farming system (Table 2). This indicates one per cent increase in expenditure in concentrate will increase gross revenue by 0.8470 per cent. Hence, it is the most important variable influencing the gross return. MVP to MFC ratio of this variable (2.769) is greater than one which indicates that resource is being used at a sub-optimal level and there exists the possibility of enhancing the gross return by increasing their use. Elasticity of labour cost was negative and significant (-0.0611) at 5 per cent level and its MVP to MFC ratio was less than one which indicate overuse of the resources.

Under S2 farming system, elasticity of concentrate cost (0.7523) and veterinary cost (0.4043) was significant at 1 per cent and 10 per cent, respectively. Goats in saline areas suffered from diseases like diarrhea, parasitic infection etc. This explains the fact that an increase in veterinary cost positively affects the gross return. MVP to MFC ratio of these variables were 2.692 and 47.86 which indicates that there is a scope for investment in these resources to increase the profitability of the farming system.

Elasticity of seed cost (0.1982), concentrate cost (0.7458) and veterinary cost (0.4337) were positive and significant in S3 farming system. Similar findings were reported by Pattihal (2015) in case of livestock-based farming systems in Karnataka and Singh *et al.* (2018) in case of an integrated farming system in Rajasthan.

Under S4 the regression coefficient of labour cost (-0.1898), fodder cost (-0.1315) and fertilizer cost (-0.0167) were negative and significant, which indicates that these variables were being utilized more than their optimum limits and increase in their use by one per cent could reduce gross return by 18.9, 13.1 and 1.6%, respectively.

In normal areas, under N1 farming system coefficient of fodder cost (0.2645), veterinary cost (0.3945) and fertilizer cost (0.7836) were positive and significant. All of their MVP to MFC ratios were greater than one, indicating that the use of fodder, veterinary and fertilizer can be increased further to obtain a higher gross return. Pattihal (2015) also found veterinary services has a positive impact on gross return of the farming system.

Elasticity of fodder cost (0.4176) under N2 also was positive and significant, it's MVP to MFC ratios were also greater than one, which show that there is ample scope for greater exploitation of these resources to maximize the production and increase the gross return. However,

Table 2. Estimates of production function coefficient and MVP to MFC ratios for farming systems in saline areas

Sl. No.	Particulars	S^1 (Sheep+ Poultry)		S^2 (Goat+ Poultry)		S^3 (Cattle+ Goat +Crop+ Fish)		S^4 (Cattle+ Poultry +Crop+ Fish)	
		Coefficients	MVP/MFC	Coefficients	MVP/MFC	Coefficients	MVP/MFC	Coefficients	MVP/MFC
1	Constant	1.3948* (0.7663)		2.0469* (1.1064)		3.2309* (1.7004)		1.6515* (0.8469)	
2	Labour cost (₹)	-0.0611* (0.0321)	-0.565	-0.0232 (0.0193)	-0.277	-0.2522 (0.2101)	-3.907	-0.1898* (0.0949)	-3.194
3	Fodder cost (₹)	-0.0406 (0.0338)	-0.130	-0.0174 (0.0133)	-0.072	-0.1749 (0.1590)	-1.784	-0.1315 (0.1143)	-1.955
4	Concentrates cost (₹)	0.8470*** (0.2823)	2.769	0.7523*** (0.1880)	2.692	0.7458*** (0.1553)	2.868	0.9464 (0.7281)	3.223
5	Veterinary cost (₹)	0.348 (0.2901)	31.881	0.4043* (0.2718)	47.86	0.4337* (0.2409)	69.366	0.2533 (0.1948)	36.911
6	Seed cost (₹/acre)	-	-	-	-	0.1982* (0.0991)	20.982	0.2218 (0.0132)	18.450
7	Fertilizer cost (₹/acre)	-	-	-	-	-0.1515 (0.1262)	-18.770	-0.0167** (0.006)	-1.631
8	Return to scale (RTS)	1.093		1.116		1.355		0.8835	
9	R^2	0.889		0.869		0.906		0.781	
10	F test	69.91		32.01		19.727		79.66	

Note: Figures in the parenthesis are respective standard error*Significant (P<0.1), **Significant (P<0.05) and ***Significant (P<0.01)

Table 3. Estimates of production function coefficient and MVP to MFC ratios for farming systems in normal areas

Sl No.	Particulars	N1 (Cattle+ Goat+ Poultry+ Crop)		N2 (Cattle+ Goat+ Crop)		N3 (Cattle+ Poultry+ Crop)	
		Coefficients	MVP/MFC	Coefficients	MVP/MFC	Coefficients	MVP/MFC
1	Constant	2.7104*(1.355)		1.3256*(0.6634)		1.9054*(0.9527)	
2	Labour cost (^{1})	-0.1183(0.0782)	-1.966	-0.1245(0.0813)	-0.4269	-0.3120*(0.1624)	-6.0624
3	Fodder cost (^{1})	0.2645*(0.132)	2.142	0.4176*(0.2092)	3.2453	0.4932(0.3288)	4.5286
4	Concentrates cost (^{1})	0.2035(0.1565)	0.6539	0.1343(0.0895)	0.8515	0.2304*(0.0791)	0.5054
5	Veterinary cost (^{1})	0.3945*(0.2131)	76.033	0.4078(0.2718)	73.303	0.3824(0.2549)	64.261
6	Seed cost (^{1}/acre)	-0.1233(0.0822)	-15.248	0.3745(0.2495)	44.445	0.4518(0.3012)	43.387
7	Fertilizer cost (^{1}/acre)	0.7836*(0.4083)	99.19	-0.1735*(0.0887)	-10.234	-0.3062*(0.1593)	-23.233
8	Return to scale (RTS)	1.4045		1.0362		0.9396	
9	R^2	0.916		0.879		0.847	
10	F test	42.495		60.094		35.758	

Note: Figures in the parenthesis are respective standard error*Significant (P<0.1), **Significant (P<0.05) and ***Significant (P<0.01)

elasticity of fertilizer in N2 (-0.1735) and N3 (-0.3062) were negative and significant which indicates that this input is utilized more than its optimum limit and an increase in their use will reduce the gross return. These findings conformed with the research findings of Kachroo *et al.* (2010) and Mathew *et al.* (2017).

Under N3 labour cost (-0.3120) also has negative and significant impact on gross return and it's MVP to MFC ratio was less than one, indicating overuse of this resource. Although, concentrate cost (0.2304) has a positive and significant effect on gross return, it's MVP to MFC ratio was less than one, indicating the use of this resources should be reduced in order to achieve higher gross return.

Unlike saline areas, green fodder is available in this region and crossbred cattle dominate the region. Few studies conducted in West Bengal by Das (2004) and Mondal (2009) had also found that green fodder and concentrate had a positive return on crossbred cows. In normal areas farmer can feed green fodder to their cattle and share of green fodder in total cost was much higher than in saline areas where green fodder was less available. Due to this reason the coefficient of green fodder was higher in normal areas than that of saline areas (Table 2 & 3). Negative and significant coefficient of labour pointing towards the presence of disguised unemployment in this region. The studies by Sekhon *et al.* (2010) and Krishna (1964) in Punjab also found a similar types of findings.

In saline area, S1 (1.093) and S4 (0.8835) farming systems had constant and decreasing return to scale respectively, while S2 (1.216) and S3 (1.355) had increasing return to sale. The return to scale value of S2 and S3 farming systems indicates, if all the selected inputs are increased simultaneously by one unit, then gross return will increase by 1.216 and 1.355 units, respectively. In terms of resource use efficiency, the study showed that S1 and S4 farming systems was only using concentrate efficiently (MVP to MFC ratio greater than one). In case of S2 farming system, both concentrate and veterinary services and for S3 concentrate, veterinary services and seed was using efficiently. Hence, based on both resource use efficiency and return to scale S2 should be recommended for landless farmers and S3 for land holders.

In normal areas, N2 (1.0362) and N3 (0.9396) farming systems had constant and decreasing return to scale, while N1 (1.4045) farming system showed increasing return to scale. While studying resource use efficiency it was found that N2 farming system was using fodder efficiently but there were no resources used efficiently by N3 farming systems. However, N1 farming system was using fodder, veterinary services and fertilizer efficiently. Hence based on both resource use efficiency and return to scale N1 farming system should be recommended for the farmers in normal areas.

The value of R^2 for S1, S2, S3, S4, N1, N2 and N3 farming systems indicated that the selected explanatory variables explained the variation of gross return by 98 per cent, 98 per cent, 87 per cent, 98 per cent, 95 per cent, 98 per cent and 96 per cent, respectively. F statistics were significant in case of all the farming systems, which indicate goodness of fit and the estimated production function significantly explained the gross return of the farming systems.

From the above analysis it was concluded that in saline area, S1 (1.093) and S4 (0.8835) farming systems had constant and decreasing return to scale respectively, while S2 (1.216) and S3 (1.355) had increasing return to sale. In terms of resource use efficiency, the study showed that S1 and S4 farming systems was only using concentrate efficiently (MVP to MFC ratio greater than one). In case of S2 farming system, both concentrate and veterinary services and for S3 concentrate, veterinary services and seed was using efficiently. Hence based on both resource use efficiency and return to scale S2 should be recommended for landless farmers and S3 for land holders.

In normal areas, N2 (1.0362) and N3 (0.9396) farming systems had constant and decreasing return to scale, while N1 (1.4045) farming system showed increasing return to scale. While studying resource use efficiency it was found that N2 farming system was using fodder efficiently but there were no resources used efficiently by N3 farming systems. However, N1 farming system was using fodder, veterinary services and fertilizer efficiently. Hence based on both resource use efficiency and return to scale N1 farming system should be recommended for the farmers in normal areas.

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