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Inter-linkages among various components of dairy based farming systems in Mizoram State

LALRINSANGPUII[1] and MALHOTRA R[2]

ICAR-National Dairy Research Institute, Karnal, Haryana 132 001, India

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ABSTRACT

Farming system approach has been widely recognized and advocated as one of the tools for harmonious use of inputs and their compounded response to make the production system sustainable. The present study was conducted to examine linkages among various components of farming systems in Mizoram state by using Leontief input-output model. The study identified 10 dairy based farming systems based on the major contribution to income of farm enterprise. The inter-component linkages from livestock to crop were stronger as compared to crop to livestock for all the farming systems. The degree of integration of different components of the various farming systems in terms of linkages is found to be strongest under D + C + P + Po farming systems. The interdependence observed among various components of farming system suggests the need to adopt total systems approach for development of sustainable farming systems.

Key words: Dairy, Farming systems, Inter-linkage, Mizoram

Farming system is a complex inter-related set of elements containing crops, dairy, piggery, poultry, fishery, sericulture, vermi-compost, *etc*., which interact among themselves. The judicious mix of the crops and animal enterprises must be based on the principle of minimizing the competition for resources and maximizing the complementarity of returns among the enterprises (Behera and Mahapatra 1999). To devise an appropriate integration of various crops, livestock and other components of agricultural system, an in-depth comprehension of farming systems is of great importance. In Mizoram, agriculture is highly complex production system where livestock production is an integral and inseparable part. Farmers in Mizoram, in general, do not practice single livestock rearing system but incorporates different livestock (cows, pigs and poultry in the backyard) to meet their domestic needs. Therefore, livestock became an integral part of farming system. The concept of man - land - livestock ecosystem is gaining momentum to maximize food production and to elevate economic status of the farmers by multifarious farm activities particularly by incorporating livestock enterprises. Besides crop cultivation which is mainly for four months in a year, marginal farmers are survived with livestock-poultry or with their subsidiary occupations (Yadav and Sharma 2013). These units are operated either alone or in combination depending upon the size of the farm holdings and other available resources. Keeping in view the importance of integrated crop-livestock farming system for substantial increase in the farmers' profit, an attempt has been made to quantify the extent of linkages prevailing under different dairy based farming systems in the study area.

MATERIALS AND METHODS

The study was conducted in Mizoram state. Out of the eight districts in Mizoram, three districts namely, Aizawl, Kolasib and Champhai were selected. The districts were selected purposively based on the net sown area, livestock population and milk production in the state. Following three stages stratified random sampling technique; two Rural Development (R D) blocks were selected randomly at the first stage from each selected district. From each of the selected block, cluster of two to three villages was selected. Thus, in all, a total of 14 villages were selected to carry out the present investigation and a sample of 180 households was selected.The primary data was collected from the selected households for the year 2014-15 consisting of two seasons, *i.e*. rainy season (June to August) and dry season (March to May).

To quantify the interdependence amongst various components of farming systems, Leontief's input-output model was used (Leontief 1966). For the purpose of

[1]Assistant Professor (Email ID: mapuii_bh@yahoo.com), College of Horticulture, Central Agricultural University, (Thenzawl), Selesih, Mizoram 796 014, [2]Principal Scientist, Division of Dairy Economics, Statistics & Management, National Dairy Research Institute, Karnal, Haryana 132 001 (Email ID: rmal1962@rediffmail.com).

analysing the linkages, the farm as a production unit was divided into several activities, *viz*. crops, dairy, piggery, poultry, fishery, labour, market and autonomous sector (farming household). Here each activity was used as a sector. The transfer of products among the various sectors of the farming system can be shown in a transaction matrix which can be read both vertically and horizontally. Horizontally, each row shows the disposal of one sector's total product for a given period of time among other sectors of the system. Vertically, each column shows the total inputs used by a sector in the given period in production and investment.

Let the n sectors denoted by S_1, S_2, …,S_n. Also, a_{ij}denotes the number of units produced by sector S_i necessary to produce one unit by sector S_j and b_i is the number of externally demanded units of sector S_i. In general, let x_1, x_2, …,x_n be the total output of sector S_1, S_2, …, S_n, respectively. Then

$$S_1 = a_{11}x_1 + a_{12}x_1 + ...+ a_{1n}x_1 + b_1 \quad (1)$$
$$S_2 = a_{21}x_2 + a_{22}x_2 + ...+ a_{2n}x_2 + b_2$$
$$S_n = a_{n1}x_n + a_{n2}x_n + ...+ a_{nn}x_n + b_n$$

An input-output model may also be described by the equation:

$$S_i = \sum Sij = H_i (i = 1,2,3,...,m; j = 1,2,3,...n) \quad (2)$$

where, S_i is the output of any intermediate sector and S_{ij} represents components flows from i^{th} sector to j^{th} sector and H_i is the final output for household consumption and market.

Equation (2) may also be written as:

$$a_{ij} = \frac{S_{ij}}{S_j} (i = 1,2,3,...,\text{m}; \text{j} = 1,2,3,...,n) \quad (3)$$

The equation (2) can also be expressed as a transaction matrix. It shows the value of output flows from the producing sectors to the consuming sectors of farm unit. Information from the transaction matrix is useful for computing relationship between inputs furnished to any one sector by other sectors and by the net output of that sector. The relationship thus obtained can be expressed in terms of production coefficients (a_{ij}) and may be described as follows:

$$S_i - \sum_j a_{ij} S_j = H_i .... \quad (4)$$

This may also be expressed as:

$$S_{ij} = a_{ij} S_j \quad (5)$$

where, S_j = total output of sector 'j'

In the above formulation, 'a_{ij}' gives the worth of a rupee of produce of 'i^{th}' sector required by sector 'j' per unit value of output of sector 'j'.

Substitution of values of 'S_{ij}' of equation (5) in equation (3) yields:

$$CE_i = \frac{E(C_i^* / \text{u}_i, P_i}{E(\text{C}_i^* / \text{u}_i = 0, P_i)} \quad (6)$$

Equation (6) represents the functional relationship between the autonomous sectors and net output (S_i) and the relationship between intermediate sectors (a_{ij}) in the farm. The inputs and outputs of various activities/enterprises was taken into value terms.

RESULTS AND DISCUSSION

The identified dairy based-farming systems in the study area were Dairy + Crop (D + C), Dairy + Crop + Piggery (D + C + P), Dairy + Crop + Poultry (D + C + Po), Dairy + Crop + Piggery + Poultry (D + C + P + Po), Dairy + Crop + Piggery + Fishery (D + C + P + F) and Dairy + Crop + Poultry + Fishery (D + C + Po + F).

The inter-linkages among the components of the various dairy based farming systems in Mizoram are given below.

Dairy + crop farming system

The inter-sectoral flows of inputs under D + C farming system has been presented in Table 1. A perusal of the table shows that the annual cattle output of ₹ 86716 required inputs from household in the form of labour worth ₹ 15784, market oriented inputs (feeds, fodder, veterinary medicines *etc*.) worth ₹ 9075 and input from crops worth ₹ 3202. In the study area, the animals provide input only in the form of manure and are not used for draft purpose due to uneven topography. In order to produce output from crops worth of ₹ 21182, FYM worth of ₹ 4748 was required. This indicates the symbiotic relationship between crop and livestock enterprises. The household sector consumed cattle products (milk and meat) worth ₹ 7806 accounting for around 9% of the total output while it was 34% in case of crop. Cattle output worth of ₹ 72099 was marketed which accounted for around 83% of total cattle product, whereas in case of crop, the share of marketed output was around 46% of its total output.

The input-output coefficients for D + C farms showed that for every rupee of cattle output, there is a requirement of household labour worth 18 paise, market oriented inputs worth 11 paise and crops worth only 4 paise. Per rupee of crop output consisted of 42 paise worth household labour, 22

Table 1 Transaction matrix under dairy + crop farming system (₹/HH/year)

Producing sector	Consuming sectors			Market	Gross returns
	Dairy	Crops	Household		
Dairy	2063 (0.024)	4748 (0.224)	7806 (0.316)	72099	86716
Crops	3202 (0.037)	959 (0.045)	7183 (0.290)	9838	21182
Household	15784 (0.182)	8951 (0.423)	9788# (0.396)	14947@	24735
Market oriented input	9075 (0.105)	2211 (0.104)	-	-	-
Total cost	30124	16869	-	-	-

Figures in parentheses are input-output coefficients, # indicates total contribution of the family labour, @ indicates total contribution of hired labour.

paise worth FYM and 10 paise worth market oriented inputs (chemical fertilizers, plant protection chemicals, irrigation water, *etc*. It may be concluded from the above analysis that cattle and crop enterprises have certain degree of linkages under D + C farming system. The inter-component linkages from livestock to crop were stronger as compared to crop to livestock.

Dairy + crop + piggery farming system

The transition matrix for D + C + P farming system has been presented in Table 2. The annual cattle output of ₹ 72099 85440 required inputs of ₹ 72099 18392 from household in the form of labour, ₹ 4418 from market oriented inputs and crops input worth ₹ 4134. The corresponding figures of input-output coefficients indicated contribution of 22 paise, 5 paise and 5 paise per rupee of cattle output. It is clear from the results of linkage coefficients that the dairy farmers mainly depend on human labour to obtain green fodder for their animals. A perusal of the table further revealed that the piggery consumed more of the crop output than cattle because pig can be fed with variety of feeds comparing with other animals. The share of household consumption in crops, piggery and cattle outputs was 16, 11 and 5%, respectively. The farmers marketed larger quantity of their produce mainly due to their economic compulsion to sell more for meeting their demand for cash and also due to higher demand of their produce in the market which fetch higher prices. The important findings that emanate on the basis of the results obtained in respect of D + C + P farming system is that a large proportion of inputs of the crops component was produced within the system. Like D + C farming system, the backward linkages were more pronounced from livestock to crop as compared to crop to livestock. It may be seen that this system used proportionally more resources from within the system as compared to D + C farming system.

Dairy + crop + poultry farming system

The results of inter-component linkages under D + C + Po farming system from Table 3 revealed that the annual output of cattle worth ₹ 111299 required inputs worth ₹ 20347 from household labour, ₹ 12392 from markets and ₹ 3808 worth crops. In case of crop enterprise, each rupee of output comprised of 29 paise of household labour, 22 paise of FYM and market oriented input contributing only 5 paise. The requirement of per rupee output of poultry for household labour, market oriented inputs and crops were 18, 13 and 5 paise, respectively. The household sector consumed cattle output of ₹ 10764 which accounted for 10 per cent of total cattle output while an output worth of ₹ 91963 was sold in the market which accounted for 83 per cent of its total output. In case of crops, the value of household consumption and sold in the market was around 21 and 61%. While poultry was mainly reared for household consumption as only 38% of the total output was sold in the market.From the above discussion, it may be concluded that though the different components of D + C + Po farming system are integrated, but the degree of integration in terms of linkages is lower than D + C and D + C + P farming systems.

Dairy + crop + piggery + poultry farming system

The quantitative relationship among various components of D + C + P + Po farming system has been presented in Table 4. It is clear from the table that the annual cattle output worth of ₹ 120783 utilized crops worth ₹ 5124. A perusal of the table further revealed that out of the total crops output, piggery and poultry obtained inputs in the form of feeds worth ₹ 1453 and ₹ 234, respectively. The household sector consumed cattle output worth ₹ 8976 which accounted for 7% of the total cattle output. The cattle output worth ₹ 104197 was sold in market accounting for 86% of the total output, whereas in case of piggery, poultry and crops it was around 81, 41 and 37%, respectively.

Table 2 Transaction matrix under dairy + crop + piggery farming system (₹/HH/year)

Producing sector	Consuming sectors				Market	Gross returns
	Dairy	Crops	Piggery	Household		
Dairy	1928 (0.023)	5504 (0.282)	0 (0.00)	4657 (0.155)	73351	85440
Crops	4134 (0.048)	1656 (0.085)	1286 (0.167)	3166 (0.105)	9299	19541
Piggery	0 (0.00)	241 (0.012)	926 (0.120)	876 (0.029)	5678	7721
Household	18392 (0.215)	9200 (0.471)	2442 (0.316)	18074# (0.602)	11960@	30034
Market oriented input	4418 (0.052)	883 (0.045)	560 (0.073)	-	-	-
Total cost	28872	17484	5214	-	-	-

Figures in parentheses are input-output coefficients, # indicates total contribution of the family labour, @ indicates total contribution of hired labour.

Table 3 Transaction matrix under dairy+crop+poultry farming system (₹/HH/year)

Producing sector	Consuming sectors				Market	Gross returns
	Dairy	Crops	Poultry	Household		
Dairy	2190 (0.020)	6382 (0.216)	0 (0.00)	10764 (0.362)	91963	111299
Crops	3808 (0.034)	1221 (0.041)	224 (0.051)	6191 (0.208)	18075	29519
Poultry	0 (0.00)	0 (0.00)	94 (0.021)	2643 (0.089)	1654	4391
Household	20347 (0.183)	8647 (0.293)	767 (0.175)	18869# (0.634)	10892@	29761
Market oriented input	12392 (0.111)	1471 (0.050)	562 (0.128)	-	-	-
Total cost	38737	17221	1647	-	-	-

Figures in parentheses are input-output coefficients, # indicates total contribution of the family labour.@ indicates total contribution of hired labour

Table 4 Transaction matrix under dairy+crop+piggery+poultry farming system (₹/HH/year)

Producing sector	Consuming sectors					Market	Gross returns
	Dairy	Crops	Piggery	Poultry	Household		
Dairy	2312 (0.019)	5298 (0.247)	0 (0.00)	0 (0.00)	8976 (0.245)	104197	120783
Crops	5124 (0.042)	1481 (0.069)	1453 (0.212)	234 (0.062)	5140 (0.140)	7975	21407
Piggery	0 (0.00)	0 (0.00)	269 (0.039)	0 (0.00)	1042 (0.028)	5541	6852
Poultry	0 (0.00)	0 (0.00)	0 (0.00)	128 (0.034)	2090 (0.057)	1537	3755
Household	22507 (0.186)	11955 (0.558)	1629 (0.238)	519 (0.138)	19614# (0.563)	16996@	36610
Market oriented input	8203 (0.068)	1262 (0.059)	864 (0.126)	767 (0.204)	-	-	-
Total cost	38146	19996	4215	1648	-	-	-

Figures in parentheses are input-output coefficients, # indicates total contribution of the family labour, @ indicates total contribution of hired labour

It may be concluded from above that, like other farming systems, the backward linkages were more pronounced from livestock to crop as compared to crop to livestock. It was also found that larger proportion of crop input was used for producing pig output comparing with the previous system.

Dairy + crop + piggery + fishery farming system

Table 5 presents the quantitative relationship among the various enterprises under D + C + P + F farming system. The input-output coefficients developed for the farm revealed that dairy output of rupee one required labour, market oriented and crops inputs worth 21 paise, 4 paise and 3 paise, respectively. In case of crops, a rupee of its output required 32, 20 and 9 paise of inputs from labour, dairy and markets. A rupee of piggery output required 20 and 19 paise of crop and labour inputs while a rupee of fishery output required 16, 11 and 8 paise input from piggery, household and market. Like other systems, the backward linkage (livestock to crop) is stronger than forward linkage (crop to livestock) in this farming system. It may be concluded from the above discussion that the degree of integration in terms of linkages is lower in this system than other farming systems in the study area.

Dairy + crop + poultry + fishery farming system

The input-output coefficients generated based on the above data in Table 6 revealed that each rupee of cattle output required inputs from household labour worth 19 paise, crop inputs worth 3 paise and market oriented inputs worth 2 paise. The share of market oriented inputs to cattle output was found to be lower on D + C + P + F and D + C + Po + F farming systems as compared to other systems. This could be due to higher number of local cattle in these

Table 5 Transaction matrix under dairy+crop+piggery+fishery farming system (₹/HH/year)

Producing sector	Consuming sectors					Market	Gross returns
	Dairy	Crops	Piggery	Fishery	Household		
Dairy	1513 (0.027)	5053 (0.197)	0 (0.00)	0 (0.00)	2740 (0.128)	46530	55836
Crops	1583 (0.028)	1436 (0.056)	1881 (0.203)	0 (0.00)	9899 (0.463)	10850	25349
Piggery	0 (0.00)	0 (0.00)	887 (0.114)	324 (0.157)	1633 (0.076)	4956	7800
Fishery	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	861 (0.040)	1202	2063
Household	11500 (0.206)	8194 (0.319)	1485 (0.190)	218 (0.106)	17393 (0.813)	4004	21397
Market oriented input	1086 (0.039)	2186 (0.085)	260 (0.033)	163 (0.079)	-	-	-
Total cost	15682	16869	4213	705	-	-	-

Figures in parentheses are input-output coefficients, # indicates total contribution of the family labour, @ indicates total contribution of hired labour

farming systems. The local cattle in the study area are neither given concentrate feeds nor any medical facilities that makes their cost of rearing comparatively lower than crossbred cattle. Per rupee of crops output required labour, FYM and market oriented inputs worth 35, 19 and 9 paise. Form the above discussion, it may be concluded that the different components of D + C + Po + F farming system are integrated but the degree of integration was found to be weakest among all the faming systems.

Conclusions and policy implications

The study of linkages helps to demonstrate the role played by various components of farming in the economic development of the people. It was observed that the crop and livestock enterprises are closely integrated components of the farming systems in Mizoram. It is evident from the magnitude of linkage coefficients that the backward linkages (livestock to crop) were stronger as compared to forward linkages (crop to livestock) under all the farming systems which is in contrast with the findings of Arya and Kalla (1992) and Shalander (1998) who reported stronger crop-livestock linkages due to substitution of manures by chemical fertilizers and bullocks by tractors in Haryana and Mathura district of UP. The crop to livestock linkages were observed generally weak which could be due to allocation of majority of the cultivated land for horticultural crops like squash, ginger, chilli, turmeric *etc*., which do not provide fodder to the animals. Being on its journey to become an organic state, the farmers depend mainly on organic manures and fertilizers that make the demand for FYM

Table 6 Transaction matrix under dairy+crop+poultry+fishery farming system (₹/HH/year)

Producing sector	Consuming sectors					Market	Gross returns
	Dairy	Crops	Poultry	Fishery	Household		
Dairy	4477 (0.071)	4367 (0.186)	0 (0.00)	0 (0.00)	6103 (0.295)	48103	63050
Crops	1586 (0.025)	1043 (0.044)	316 (0.107)	0 (0.00)	4119 (0.199)	16466	23530
Poultry	0 (0.00)	0 (0.00)	305 (0.103)	0 (0.00)	1108 (0.053)	1551	2964
Fishery	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	926 (0.045)	1566	2492
Household	11872 (0.188)	8218 (0.349)	321 (0.108)	309 (0.124)	15513 (0.749)	5207	20720
Market oriented input	1334 (0.018)	2054 (0.087)	349 (0.118)	143 (0.057)	-	-	-
Total cost	19069	15682	1292	452	-	-	-

Figures in parentheses are input-output coefficients, # indicates total contribution of the family labour, @ indicates total contribution of hired labour

high in the study area which in turn lead to strong cattle to crop linkages. The degree of crop to livestock integration of different components of the various farming systems in terms of linkages is found to be strongest under D + C + P + Po farming systems as piggery enterprise consumed larger proportion of crop inputs. It is also observed from the above analysis that the degree of integration from crop to piggery was stronger than crop to cattle due to wide eating habit of pigs which can be fed with variety of crops.

The interdependence observed among various components of farming system suggests the need to adopt total systems approach for development of sustainable farming systems. Strong livestock to crop linkages were observed in all the farming systems. The weak crop to livestock linkages observed in the study suggests the need for strengthening linkages through utilization of by-products of different crops as livestock feed and cultivation of fodder in the field. This is expected to enhance economic viability and long term sustainability of farming systems.

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