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# Diversification Leading to Co-dependency among the Sub-components: An Empirical Study from Haryana

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**Abstract**

*Dairy based farming system models are widely adopted in the whole country for ensuring regular flow of income along with supplementing the dietary requirements of the household. A farming system can be termed as an integrated farming system, if and only if, the component enterprises have a certain level of dependency on each other. Hence the present study was undertaken to assess the extent of co-dependency among crop + dairy (IFS-I), crop + dairy + mushroom (IFS-II) and crop + dairy + apiary (IFS-III) models in Haryana. A total of 100 respondents were randomly selected from the four districts, namely, Hisar, Karnal, Sonipat, and Kaithal. The results have suggested that there exists certain degree of linkage among the components of IFS models under study, and majority of the inputs were provided from within the system. It was evident from these three models that crop enterprise had stronger influence on dairy enterprise as it was providing feed and fodder to the livestock but in return weaker linkages were observed between dairy and crop enterprises as the farmers were shifting towards agrochemicals instead of using organic sources of manuring.*

**Keywords:** Linkage, Leontief's input-output model, Integrated farming system models.

**JEL Classification:** C67, D57, Q12, Q1

## Introduction

The integration of crop and livestock is the one of the commonly practiced farming system models in India (Vaidyanathan, 1998; Devendra *et al*., 2000; Singh *et al*., 2021). Marginal and small farmers tend to rear animals for meeting the livelihood requirements through regular income and food security, better resource management, and coping with risks involved in farming (McIntire et al., 1992; Pell,1999; Thornton and Herrero, 2001; Kristjanson and Thornton, 2004; Williams et al., 2004; Lenne and Thomas, 2006). These farming system models can be termed as integrated farming system models iff the component enterprises are dependent on each other for meeting their input requirements. It can be challenging to understand the resource dynamics of crop-dairy farming systems (Iiyama et al., 2007) but identification and quantification of linkages in the dairy based integrated farming system could help in comprehending the interdependence upon each other. This quantification can further help in fortifying the interdependence resulting in better on-farm resource utilization and efficiency. Haryana ranked 8th in the top milk producing states of India (Basic Animal Husbandry and Fisheries Statistics, 2017) but the per capita milk availability in Haryana was 1,118 g/day in comparison to the 406 g/day of the national average and stood second only to Punjab (1221 g/day) during 2019-20 (NDDB).

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## Data Sources and Methodology

Haryana is among the top ten milk producing states of the country but stands second in terms of per capita milk availability/day, hence the state was purposively selected. The present investigation comprised of 100 IFS adoptee farmers from the four districts of Haryana, viz., Hisar, Karnal, Sonipat, and Kaithal. A total of three dairy based integrated farming system (IFS) models were studied. i.e., crop + dairy (IFS-I), crop + dairy + mushroom (IFS-II) and crop + dairy + apiary (IFS-III). Within these models, thirty respondents were interviewed from IFS-II and IFS-III while forty respondents were selected from IFS-I.

For calculating the total cost incurred and returns observed from different enterprises of IFS models, primary data were collected on the cropping pattern and crop rotations followed; herd size and composition; quantity of inputs utilized under crop, dairy, apiary, and mushroom enterprises

along with their per unit cost; utilization of both family and hired labour within different enterprises; utilization pattern of both owned and borrowed capital, disposal pattern of main and by-products of the agricultural activities; and flow of resources within the integrated farming system during 2020-21. For certain aspects like, effect of bees on cross-pollination and seed replacement ratio were collected from secondary sources.

The seed replacement rate for crops in current study was accounted as 37.43 per cent, thereby suggesting that majority of the seed and planting materials used in cropping system was provided by its past produce. Past reports on seed replacement rate for paddy in Haryana has also revealed it to be 30.48 and 33.80 per cent in 2017 and 2011 whereas the seed replacement rate for wheat was 30.48 per cent during 2011 (agricoop.nic.in). Hence, these data were considered while calculating the contribution of crop enterprise for itself.

## Identification of Linkages within the Integrated Farming Systems

Farming system models were identified based on the prominently adopted integrated farming system models in the study. On a closer inspection of the study area, it was revealed that rearing cattle along with crop cultivation was the most prevalent model in Punjab and Haryana, hence focus was given to the models with crop and livestock in the present study (Singh *et al*, 2021). Leontief's input-output model was used for quantifying the co-dependence amongst various components of farming system (Leontief, 1966).

In order to identify and quantify the existing linkage within the production unit, component enterprises of the farming system were treated as separate sectors viz., crop sector, dairy sector, mushroom sector, apiary sector, labour sector, market sector and farm household sector. It was assumed that each sector required a combination of inputs which was partially fulfilled from itself and partially from the other sectors of the farm economy. Any off-farm input was assumed to be purchased or hired-in from the market sector. For example: in order to produce a unit output from crop sector, inputs were met by crop, dairy, market and farm household sectors and the resultant output was also distributed or sold onto these sectors to meet their input requirements.

Any biomass of plant origin produced on the farmer's field was considered an output from the crop sector. Thus, in the present study, crop production comprised of the main and by-products from field crops, horticultural crops and fodder crops grown on the farms. The output from dairy sector was accounted in terms of sale of milk, FYM and calves for crossbred cow, buffalo and indigenous cow. In terms of mushroom sector, only the output value of mushroom was considered. For apiary sector, output of honey, bee-wax and bee colonies were accounted for in the present study.

All the estimations for quantifying the linkage between sectors of the farming system model were based on the survey data. Transaction matrix was formed on the basis of all the monetary transfer of inputs and outputs among the various sectors of the farm economy and could be read both horizontally and vertically. Horizontally, each row represented the monetary value of total product of one sector offered/sold to other sectors of the economy during one year. Similarly, each vertical column displayed the total inputs used/purchased by the individual sector from the corresponding sectors of the economy in a year.

Let, n number of sectors in the economy be denoted by $S_1$, $S_2$, ..., $S_n$ Similarly, let the number of units produced by sector necessary to produce one unit by $S_j$ sector be denoted by $c_{ij}$; and number of externally demanded units of sector $S_i$ be denoted by $d_i$; and the total output of $S_1$, $S_2$, ..., $S_n$ sector be denoted by $x_1$, $x_2$, ..., $x_n$ respectively. Then, the resultant equations will be:

$$S_1 = cx_1 + c_{12}x_1 + ... + c_{1n}x_1 + d_1 \quad (1)$$

$$S_2 = c_{21}x_2 + c_{22}x_2 + ... + c_{2n}x_2 + d_2$$

$$S_n = c_{n1}x_1 + c_{n2}x_n + ... + c_{nn}x_n + d_n$$

An input-output model may be denoted by the following equation:

$$S_i = \Sigma S_{ij} + E_i \quad (2)$$

where,

i = 1,2,3,…, m

j = 1,2,3,…, n

$S_i$ = the output of any intermediate sector

$S_{ij}$ = component flows from sector to sector and,

$E_i$ = final output for household consumption and market.

Equation (2) may be expressed as:

$$S_i = \Sigma S_{ij} + E_i \quad (3)$$

The equation (2) can also be demonstrated as a transaction matrix, representing the value of output circulating 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 individual sector by itself and the adjoining sectors of the economy The resultant relationship can also be expressed in terms of production coefficients ($c_{ij}$) as follows:

$$c_{ij} = \frac{S_{ij}}{S_j} \quad (4)$$

Equation (4) may also be re-written as:

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

where, $S_j$ = total output of sector '$j$'

In the equation (4) and (5), '$c_{ij}$' refers to the worth of a rupee of output of '$i^{th}$' sector required by sector 'j' per unit value of output of sector 'j'.

Upon substituting the values of '$S_{ij}$' of equation (5) in equation (3), the resultant equation is:

$$S_i = \Sigma c_{ij} S_{ij} = E_i \quad (6)$$

Equation (6) represents the functional relationship between the independent sectors, net output ($S_i$) and the relationship between intermediate sectors ($c_{ij}$) in the farm economy. The monetary value of inputs and outputs of all the enterprises was taken into account for fulfilling this objective.

## Results and Discussion

The study reveals that crop sector was supporting dairy sector through furnishing grains and fodder crops for livestock whereas dairy sector was providing organic manure to the crop sector. However, a decline in dependence from crop on dairy sector was observed due to shift towards synthetic manure from organic sources; and employment of mechanical labour instead of draught power for saving time, energy and increasing the work efficiency. The crop sector was providing inputs for dairy, mushroom, apiary, household and market sectors whereas it was receiving inputs from crop, dairy, apiary, household and market sectors of the farm economy. The yield enhancement in cross-pollinated crops due to apiary sector were calculated at 20 per cent, based on the past research findings in case of rapeseed & mustard, and sunflower crops as 12.8 to 48.2 per cent (Duraimurugan and Reddy, 2018). Fig. 1, Fig. 2 and Fig. 3 showcases the flow of resource observed between the component enterprises of the respective IFS-I, IFS-II and IFS-III models of Haryana.

The average farm size under the three IFS models of Haryana belonged to semi-medium category, of which highest area was observed under IFS-III model (Table 1).

The highest area was allocated to paddy and wheat while lowest was allocated to vegetable crops during respective seasons of *kharif* and *rabi* as paddy-wheat is the prevalent cropping rotation followed in Haryana. The average cost of cultivation (per farm) for *Kharif* and *Rabi* crops in Haryana were reported as Rs. 1.59 lakhs and Rs. 80 thousand, respectively. The cropping intensity for Haryana was calculated to be 200 per cent which was in consonance with the reports of Statistical Abstract of Haryana (2020-21).

The average milk yields for milch animals were also reported as 89.29 litres/farm with a total annual cost of Rs. 6.67 lakhs for all the farms of Haryana. Mushroom enterprise was found only within IFS-II model and apiary was included only in the IFS-III model, hence their calculations were restricted only to their respective models (Table 3).

Table 4 provides the detailed information about the input-output coefficients for IFS-I: crop + dairy model of Haryana. The annual gross returns of Rs. 4.63 lakh from crop enterprise was achieved on the expense of Rs. 6,571 from crop enterprise, Rs. 6,368 from dairy enterprise as FYM and

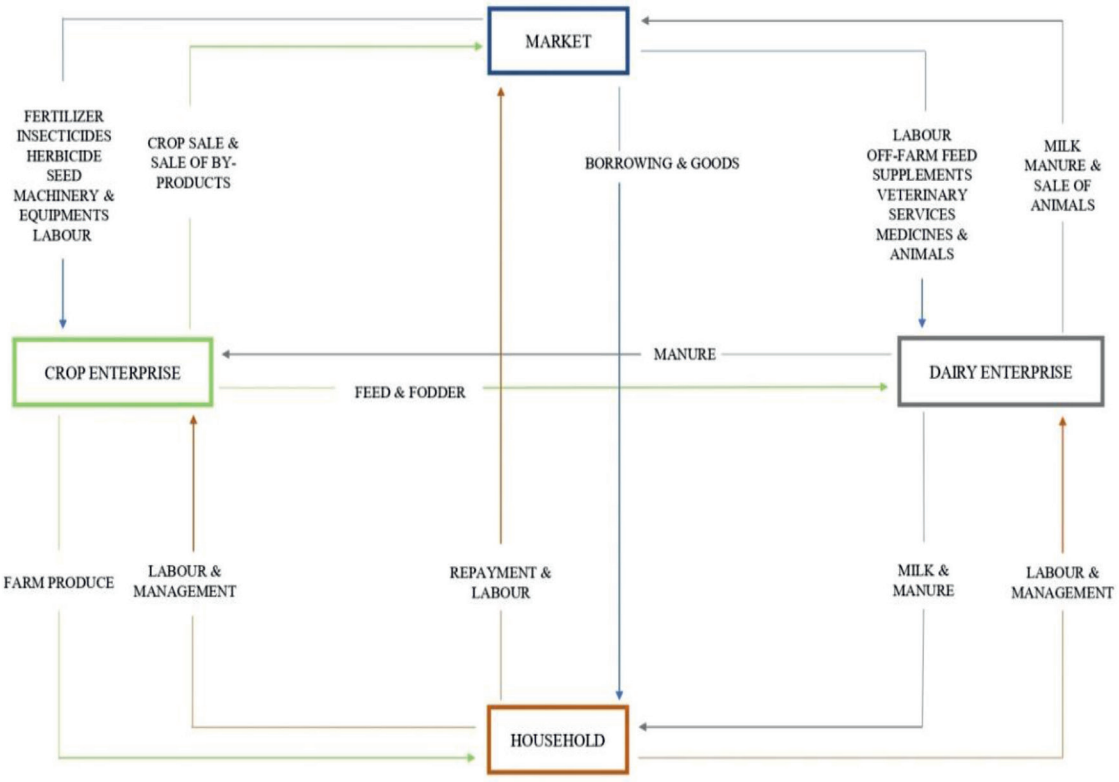


**Fig 1.: Resource flow chart for IFS-I model**

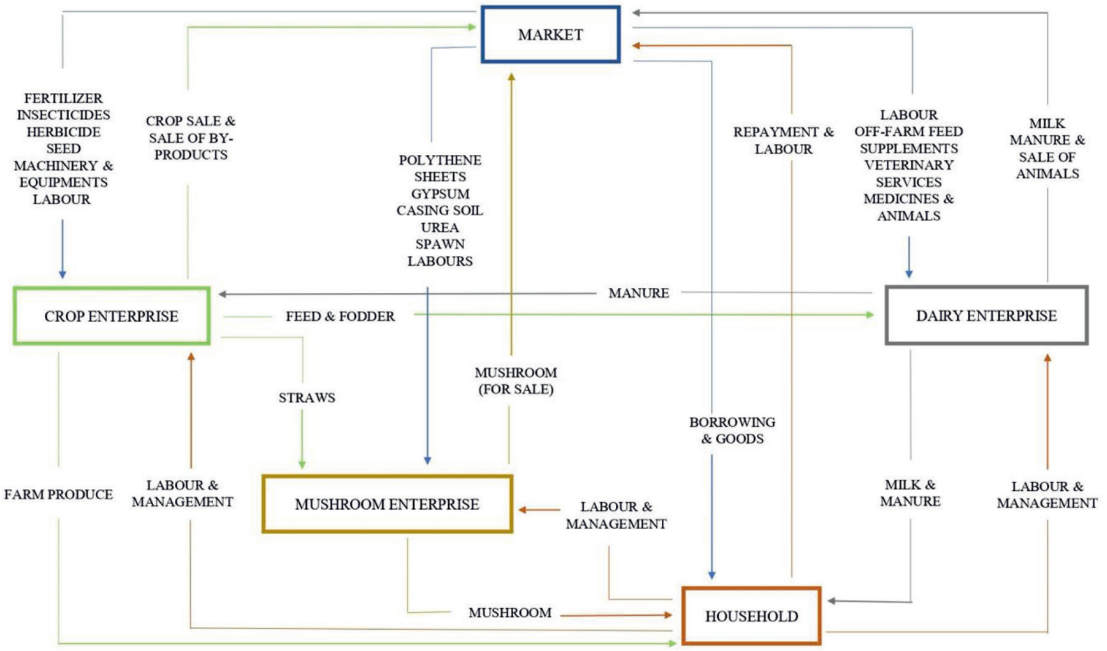


**Fig 2.: Resource flow chart for IFS-II model**

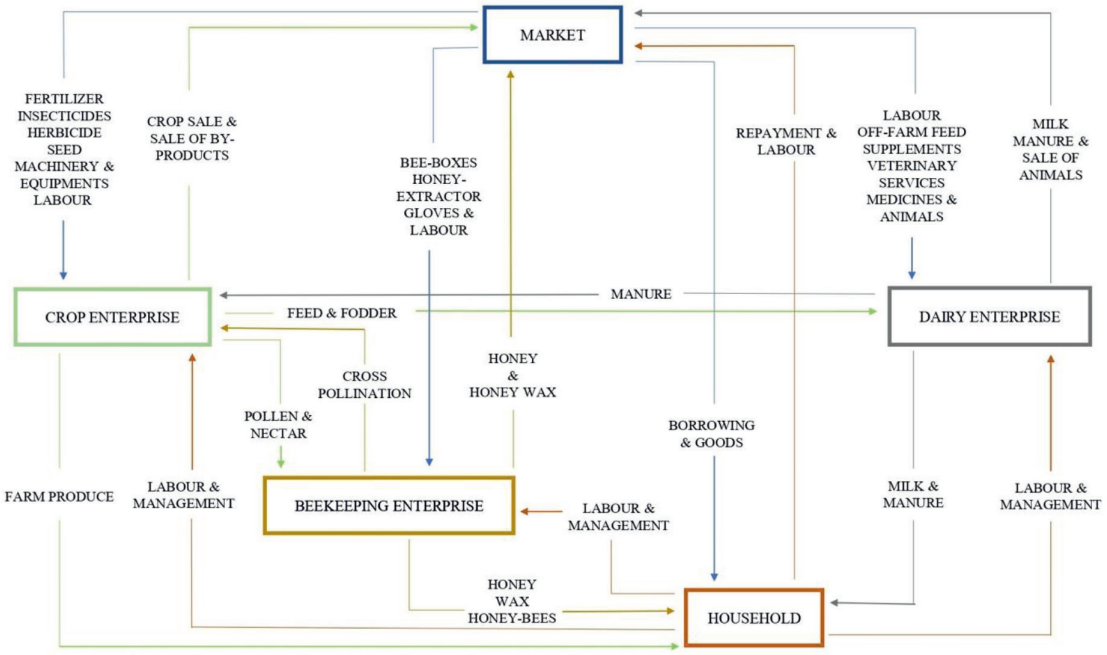


**Fig 3.: Resource flow chart for IFS-III model**

Rs. 64 thousand from household as implicit charges and Rs. 93 thousand from explicit charges paid to the hired resources. For dairy enterprise, it was again observed that for every one rupee earned from dairy enterprise, 76.3 paise was invested from within the system, indicating that for dairy enterprise, the system was self-sufficient. It was observed that input-output linkage of dairy-crop (0.014) was weaker than the input-output linkage of crop-dairy (0.044). It was found that out of the total crop and dairy output, only eight per cent and seven per cent were kept for meeting the family requirement and the rest 84 per cent and 92 per cent of the produce was sold. It was also revealed that out of the total employment generated within this model, around 40 per cent was met by the family labour and 60 per cent of the labour was hired.

**Table 1. Average landholding size of IFS models in Haryana**

(ha)

| IFS models | Crop (ha) | Dairy (herd-size) | Mushroom (ha) | Beekeeping (beehives) | Total (ha) |
|---|---|---|---|---|---|
| IFS-I | 2.04 | 8.70 | – | – | 2.14 |
| IFS-II | 2.14 | 10.59 | 0.09 | – | 2.34 |
| IFS-III | 2.38 | 10.13 | – | 143 | 2.90 |

*Source: Field survey*

The transaction matrix for crop + dairy + mushroom integrated farming system for the state of Haryana has been presented in the Table 5, wherein the annual gross returns from crop, dairy and mushroom enterprise from IFS-III farms has been discussed. The annual gross return of Rs. 4.33 lakh from cropping enterprise required inputs worth Rs. 7,520 from crops, Rs. 7,748 from dairy and Rs. 59,334 from household and Rs. 98,670 from market-oriented inputs. The corresponding figures of input-output coefficients indicated contribution of 2 paise, 2 paise, 14 paise and 23 paise towards per rupee of crop output. Dairy enterprise was self-sufficient as the system supplied 70.2 paise of inputs for every one rupee of output. Market oriented inputs had the highest share of 59.3 paise as majority of the feed and fodder and labour accounts under explicit cost and crop enterprise has a share of 3 paise by providing green fodder towards dairy output. The cost of mushroom enterprise included variable cost, fixed cost and capital investments done, wherein it was revealed that the sum of input-output coefficients (0.660) was near to one, hence proving that this component had higher interdependence on the sub-sectors of this model. It was clear from the linkage coefficients that contribution of crop enterprise towards dairy enterprise (0.027) was larger than the linkage coefficient of crop enterprise for dairy enterprise (0.018), indicating that the contribution of FYM towards crop output was less than the contribution of green fodder, dry fodder, and grains towards dairy output. There were weak linkages in both the cases, but input-output linkage of dairy-crop was weaker than the forward linkages (crop-livestock) in the model. Out of the total crop, dairy and mushroom produce, respective shares of 77 per cent, 87 per cent and 96 per cent were sold out in the market and only 10 per cent, 13 per cent and four per cent were kept for household consumption. In this integrated farming system model, 45 per cent of labour employment was met by the family labour and 55 per cent labour was hired out.

The transaction matrix for IFS-III model comprising of crop enterprise, dairy enterprise, apiary activity, household,

**Table 2. Average cost of cultivation and returns for kharif and rabi crops cultivated across different IFS models in Haryana**

(Rs. per farm)

| Kharif season | Average area (ha) | Cost of cultivation | Gross returns | Rabi season | Average area (ha) | Cost of cultivation | Gross returns |
|---|---|---|---|---|---|---|---|
| Paddy | 1.63 | 139429.21 | 372370.03 | Wheat | 1.69 | 64941.73 | 151019.56 |
| Cotton | 0.19 | 11019.66 | 24672.35 | Oilseeds | 0.20 | 6456.30 | 17369.40 |
| Maize | 0.10 | 2221.29 | 5085.32 | Gram | 0.16 | 5151.70 | 11360.69 |
| Vegetable | 0.09 | 475.06 | 1599.73 | Vegetable | 0.04 | 328.82 | 1240.64 |
| Fodder | 0.16 | 5780.10 | 14565.16 | Fodder | 0.08 | 3021.72 | 13933.38 |
| Total | 2.17 | 158925.32 | 418292.59 | Total | 2.17 | 79900.27 | 194923.67 |
| Gross Cropped Area | | | | | 4.33 | | |
| Cropping Intensity | | | | | 200.00 | | |

*Source: Field survey*

**Table 3: Cost and returns from different enterprises**

(per farm)

| Particulars | Dairy | Mushroom | Apiary |
|---|---|---|---|
| Total cost | 667370.22 | 392080.79 | 155218.82 |
| Annual yield (in kg) | 27233.05 | 6044.67 | 2956.62 |
| Gross returns | 856872.51 | 594238.41 | 434881.00 |

**Table 4. Transaction matrix for crop + dairy IFS model in Haryana, 2019-20**

(Rs. per farm per year)

| Producing sectors | Consuming sectors | | | Market | Gross returns |
|---|---|---|---|---|---|
| | Crop | Dairy | Household | | |
| Crop | 6571<br>(0.014) | 34054<br>(0.044) | 35447<br>(0.183) | 394607 | 463464 |
| Dairy | 6368<br>(0.014) | — | 57502<br>(0.297) | 716027 | 779897 |
| Household | 63671<br>(0.137) | 70344<br>(0.090) | 22790@<br>(0.401) | 116094# | 193884 |
| Market oriented input | 92692<br>(0.200) | 490971<br>(0.630) | — | — | — |
| Total cost | 169302<br>(0.365) | 593369<br>(0.763) | — | — | — |

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

**Table 5. Transaction matrix for crop + dairy + mushroom IFS model in Haryana, 2019-20**

(Rs. per farm per year)

| Producing sectors | Consuming sectors | | | | Market | Gross returns |
|---|---|---|---|---|---|---|
| | Crop | Dairy | Mushroom | Household | | |
| Crop | 7520<br>(0.017) | 27533<br>(0.027) | 21721<br>(0.037) | 42685<br>(0.126) | 333157 | 432616 |
| Dairy | 7748<br>(0.018) | — | — | 130338<br>(0.385) | 888079 | 1026165 |
| Mushroom | — | — | — | 24255<br>(0.072) | 569983 | 594238 |
| Household | 59934<br>(0.139) | 84692<br>(0.083) | 224734<br>(0.548) | 152062@<br>(0.449) | 186805# | 338867 |
| Market oriented input | 98670<br>(0.228) | 608229<br>(0.593) | 145625<br>(0.245) | — | — | — |
| Total cost | 173872<br>(0.402) | 720454<br>(0.702) | 392801<br>(0.660) | — | — | — |

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

and market was discussed in the Table 6. The sum of input-output coefficients for crop (0.340), dairy (0.729) and apiary enterprise (0.357) suggest that within this integrated farming system, dairy enterprise was highly supported by the enterprises within the system followed by crop and apiary. Out of the total output from crop, 79 per cent was sold in the market and nine per cent was held onto for household consumption. In case of dairy and apiary activity, 90 per cent and 92 per cent of the output was marketed surplus and only nine per cent and four per cent of the output was used for household consumption. Almost 54 per cent of the employment generated in this IFS model was hired out while 46 per cent was supplied from the household.

## Conclusion and Policy Implications

The results of the present investigation confirm the existence of forward and backward linkages among the sectors (components) of the IFS models to certain degree with more than one corresponding sectors. All the surplus produce set aside after meeting the requirements of farm and family was sold in the market and no ambiguity was observed between marketed and marketable surplus thereby striking the existence of distress sale in the study area. The cultivated fodder crops on the farm were unable to fulfill the yearly requirements of the dairy, therefore overall weak forward linkages were observed between the crop and dairy enterprise

**Table 6: Transaction matrix for crop + dairy + apiary IFS model in Haryana, 2019-20**

(Rs. per farm per year)

| Producing sectors | Consuming sectors | | | | Market | Gross returns |
|---|---|---|---|---|---|---|
| | Crop | Dairy | Beekeeping | Household | | |
| Crop | 7941 (0.016) | 39717 (0.043) | 13285 (0.031) | 46212 (0.245) | 400352 | 507506 |
| Dairy | 7415 (0.015) | — | — | 84336 (0.447) | 836292 | 928043 |
| Beekeeping | 15942 (0.031) | — | — | 16739 (0.089) | 402200 | 434881 |
| Household | 66937 (0.132) | 79564 (0.086) | 93326 (0.215) | 59105@ (0.313) | 129554# | 188658 |
| Market oriented input | 74296 (0.146) | 556811 (0.600) | 48608 (0.112) | — | — | — |
| Total cost | 187596 (0.340) | 676092 (0.729) | 155219 (0.357) | — | — | — |

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

in Haryana. The relationship between forward linkages (crop-livestock) were revealed to be stronger than the dairy-crop input-output linkage in all the IFS models of Haryana. Similar result was reported in previous investigations of Arya and Kalla (1992), Shalander (1998), Sangpuii (2017).

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## References

Arya S and Kalla J C 1992. A study in estimation of linkages for crop-cattle production activities in Haryana. *Indian Journal of Agricultural Economics* **47**:653-59.

Basic Animal Husbandry Statistics 2017. Ministry of Agriculture and Farmers Welfare. Department of Animal Husbandry and Dairying, Government of India. https://www.nddb.coop/information/stats/percapitavail

Devendra C, Thomas D, Jabbar M, and Zerbini E 2000. Improvement of livestock production in crop-animal systems in agro-ecological zones of South Asia. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Duraimurugan P and Reddy A V 2018. ICAR-Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad, Telangana, India. https://vikaspedia.in/agriculture/crop-production/package-of-practices/oilseeds/role-of-honey-bees-in-pollination-of-oilseed-crops.

https://agricoop.nic.in/sites/default/files/SRR.pdf

GOH 2018. The Economic Survey of Haryana, 2017-18.

GOH 2020-21. Statistical Abstract of Haryana, 2020-21.

Iiyama M, Kaitibie S, Kariuki P, and Morimoto Y 2007. The status of crop–livestock systems and evolution toward integration. *Annals of Arid Zone* **46**:1-23.

Kristjanson P M and Thornton P K 2004. Methodological challenges in evaluating impact of crop–livestock interventions. In: Williams, T. O., S. A. Tarawali, P. Hiernaux, and S. Fernández-Rivera (Eds). Sustainable crop-livestock production for improved livelihoods and natural resource management in West Africa. Nairobi, International Livestock Research Institute, Kenya pp160-172.

Lenné J M and Thomas D 2006. Integrating crop livestock research and development in sub-Saharan Africa. Option, imperative or impossible? *Outlook on Agriculture* **35**: 167–175.

Leontief W 1966. Input-Output Economics. Oxford University Press, New York.

McIntire J, Bourzat D and Pingali P 1992. Crop-Livestock Interaction in Sub-Saharan Africa. World Bank Regional and Sectoral Studies. The World Bank, Washington, DC.

Pell A N 1999. Integrated crop-livestock management systems in Sub-Saharan Africa. *Environment, Development and Sustainability* **1**: 337-48.

Sangpuii L 2017. Economic analysis of dairy based farming systems in Mizoram state. Ph.D. dissertation. ICAR-National Dairy Research Institute, Karnal, India.

Shalander K 1998. Economic analysis of farming systems in Mathura district of Uttar Pradesh. Ph.D. dissertation. ICAR-National Dairy Research Institute, Karnal, India.

Singh J, Riar T S and Garg L 2021. Prospects of integrated farming system in Punjab. *Journal of Community Mobilization and Sustainable Development* **16**:313-15.

Thornton P K and Herrero M 2001. Integrated crop-livestock simulation models for scenario analysis and impact assessment. *Agricultural Systems* **70**: 581-602.

Vaidyanathan A 1998. Programme for research on mixed crop-livestock systems in South Asia: A tentative outline. Report submitted to the ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Patancheru, India.

Williams T O, Tarawali S A, Hiernaux P and Fernandez-Rivera S (Eds.) 2004. Sustainable crop livestock production for improved livelihoods and natural resource management in West Africa. International Livestock Research Institute), Nairobi, Kenya and CTA (Technical Centre for Agricultural and Rural Cooperation, ACP-EC), Wageningen, The Netherlands.

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