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Remunerative Potential of Small Ruminants (Sheep and Goat) under Rainfed Conditions in the Jammu Region of South Asia

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ABSTRACT

Background: India has large rainfed area in her possession, rather, India is holding first position in the possession of rainfed area. At the same time, India has large share of small ruminants (sheep and goats) in her stockpile of livestock. This paper is an effort towards finding out the mutual compatibility between the two.

Methods: The study was conducted during 2020-21 in the rainfed areas of Jammu region, in three main districts *i.e.*, Kathua, Udhampur and Rajouri, respectively. The technique of production function was applied to ascertain the resource use efficiency so as to find out the inputs that yielded maximum returns to the farmers. In addition, linear programming was applied so as to find out the optimisation of returns, respectively.

Result: Profitability was found to be higher for Rajouri district (Rs. 12.79 per ruminant per day). 'Selling of mutton' formed the major component of gross returns in Kathua and Udhampur district, respectively. Production function analysis revealed 'concentrates' (0.219) in Kathua district and 'labour' (3.559) in Udhampur district as the important inputs in the small ruminant's enterprise. The labour was found in large numbers there, but there is paucity of training of labour. In this regard, the paper recommends the proper training measures for the labour engaged in this enterprise. Moreover, there is large variations (as depicted by linear programming) in the optimisation of the inputs (cash outlay and labour requirements) within the districts and this needs to be adjusted appropriately. These adjustments need to be made so that small ruminant's enterprise can act as the bulwark against the looming threat of climate variations.

Key words: Linear programming, Production function, Rainfed area, Small ruminants.

INTRODUCTION

Rainfed areas are the areas which are predominantly dependent upon the rainfall for their irrigation requirements. As they are deficient in irrigation requirements, high productivity of the crops cannot be manifested into reality. To counter this situation, the farmers in these regions are primarily been engaged themselves in the allied agricultural enterprises as well. One of the common allied enterprises they practiced is the rearing of the small ruminants. Most of the farmers in these regions are in possession of small ruminants because of their stoutness and sturdiness (Roba *et al*., 2017, Pathania and Dev, 2015) to the harsh climates. In addition, the cost of rearing small ruminants is not beyond the scope of the already constrained-poor farmers of these regions.

Jammu is located in the northern India, in the South Asian region and the area under this region as a whole is better defined and categorised to be as predominantly rainfed (Digest of Statistics, 2018-19). Moreover, the localities in this rainfed regions have been rearing small ruminants since time immemorial. No doubt, these small ruminants help them in supplementing and even augmenting their income, but still, there is a huge scope of improvement in the rearing of these ruminants, so that the income of these farmers can further been enhanced.

It would be pertinent at this point of time to expand our horizon beyond the income level of the farmers, to that of sustainability. Climatic variability is a real threat in the near future. It therefore turns out to be very imperative that the income enhancement strategies should be sustainable, whereby fodder leaves and tree leaves needs to be conserved, so as to mitigate the deleterious impact of the dry zones (Shinde *et al*., 2020). Rehabilitation of community lands is another area of focus (Shinde and Mahanta, 2020). With the rising threat of climatic variability, there will be myriad of problems for the food security. In this sense, small ruminants can play its effective role in containing the problem of food security to some extent security (Devendra, 2016; Haddad *et al*., 2011).

No effective study was conducted in evaluating the efficacies of the different inputs in enhancing the income of the farmers engaged in the small ruminants. Therefore, the present study is a contribution towards finding out the usefulness of the rearing of small ruminants in the rainfed areas of Jammu region. Moreover, the study also assumes

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its importance due to the existence and prevalence of immense rainfed area in the nation (NRAA, 2016). The study, in addition, becomes important in the context of presence of large share of population of small ruminants (sheep and goat) in the nation with respect to the other livestock (Fig 1). In essence, the present paper is an effort towards mapping out the mutual compatibility of the large stocks of small ruminants (Fig 2) in India with that of the large rainfed area, in the backdrop of the rising threat of climatic variability.

MATERIALS AND METHODS

Data were collected with the help of scientifically prepared schedules from the respondents of three main areas of Jammu region *i.e.*, Kathua, Udhampur and Rajouri, respectively (Fig 3 and 4). These regions were selected purposively for the study as there were large presence of rainfed areas in the said regions, respectively.

In the present study, sheep and goat farm were integrated together so as to find out the combined effect of the two types of small ruminants on the income of the farmers. In this context, the flock size of the two types has not been segregated, rather, it has been kept as an integrated unit so as to reduce the complexity involved in the segregation of the two types of small ruminants. The average area of goat farms and sheep farms were of around 1 hectare. As far as the flock size is concerned, it varies to a certain extent. The average flock size in Kathua district found out to be around of 10 to that of 35 in case of Rajouri.

Surrounded by Jammu district to northwest, Doda and Udhampur districts to the north, state of Himachal Pradesh to the east and Punjab to south, Kathua district is consisting of rich agricultural areas along the Punjab/Kashmir border areas. Located at 32° 37′N to 75° 52′E and as per the 2011 census, total population of the district stands about 6.16 lakh with the population density of 246 inhabitants per square kilometre. As per the agriculture contingency plan, wheat and maize are the major rainfed crops in this region. Millets and pulses are some other crops that are grown in the rainfed region. Apple, pear, citrus and mango are the major horticultural rainfed crops.

Udhampur name of the district was inspired from Udham singh, the eldest son of Maharaja Gulab Singh, the founder of Dogra rule in Jammu and Kashmir. The latitude of the district lies between 32° 34′ to 39° 30′N and the longitude of the district lies between 75° 38′ E. As per the 2011 census, the district has a population of about 5.55 lakh with a population density of 211 inhabitants per square kilometre.

Rajouri is encircled to its west by the line of control, to its north by Poonch and to its south by Nowshera and Chamb. As per 2011 census, the district has the population of about 6.42 lakh, population density of the district is about 235 inhabitants per square kilometre, sex ratio is 863 females per thousand males and the literacy rate is 68.54 percent. According to the agriculture contingency plan of the district, the district has an attitude of 32° 55′N and the longitude of 75° 11′E. The major rainfed crops in the region are maize, wheat, millets, pulses. The major rainfed horticultural fruit crops include apple, pear, apricot, citrus and mango.

Apart from the usual cost and returns principles, functional analysis of the study was carried out by Cobb-Douglas Production function. This function was selected as this function measure the contribution of each input to that of total output along with giving details about the returns to scale. In addition, the coefficient of multiple determination (R^2) was also calculated. It reflected the total percentage of variation in the dependent variable was being explained by the set of independent variables, respectively.

The general form of production used in the analysis is as follows:

$$Y_t = \beta o\ (\Pi^{n}_{i=1} Xi^{\beta i})\ u\ (i = 1, 2, 3....n)$$

Where;

'Y'and X_i (i=1,2,3,.....n) represents the levels of output and levels of inputs. In addition, the respective constants. βo and βi's (i = 1,2,3....n) reflects the efficiency parameters as well as the production elasticities of the particular input variables for the given population at a particular period 't'. The term 'u' represents the error term.

The fitted Cobb-Douglas production may be represented in the mathematical form for the present case with six input variables (in case of crops) as follows:

$$Y = a_o X_1^{b1} X_2^{b2} X_3^{b3} \ldots\ldots\ldots\ldots\ldots X_n^{bn} e^n$$

In the above functional model,

'Y' = Depicts the dependent variable.

'X_i' = Depicts the independent variable.

'a' = Constant representing the intercept or the production function and finally.

'bi' = Reflects the regression coefficients of the respective resource variables.

Subsequently, the above function has been modified into logarithmic transformation to suit the specific needs of the study:

$$\text{Log } Y = \text{Log } a + b_1 \text{ Log } X_1 + b_2 \text{ Log } X_2 + \ldots\ldots\ldots + bn \text{ Log } Xn + u \text{ Log } e$$

The fitted Cobb-Douglas production for the present case with six variables has been represented as follows:

$$Y = a_o X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6}$$

Where;

Y = Gross returns of the small ruminant's enterprise in rupees per small ruminants per day as a dependent variable.

X_1 = Total cost on dry fodder in rupees per small ruminants per day.

X_2 = Total cost on green fodder in rupees per small ruminants per day.

X_3 = Total cost on concentrates in rupees per small ruminants per day.

X_4 = Total cost on labour in rupees per small ruminants per day.

X_5 = Total cost on medicine and veterinary care in rupees per small ruminants per day.

X_6 = Total cost on miscellaneous items in rupees per small ruminants per day.

MVP was worked out so as to reflect the addition of gross value of farm production per unit increase in the 'ith' resource, with all the resources kept fixed at their geometric mean levels. The MVP for the small ruminant's enterprise in the study area was calculated by utilizing the following formula (Heady and Dillion, 2002):

$$MVP = b \frac{\overline{Y}}{\overline{X}} P_y$$

Where;

b = Regression coefficient of particular independent variable.

$\overline{Y}$ = Geometric mean of dependent variable.

$\overline{X}$ = Geometric mean of independent variable.

P_y = Price of dependent variable.

Statistical significance was measured by t-statistic *i.e.*,

$$\text{t-statistic} = \frac{\text{Regression coefficient}}{\text{Standard error}}$$

It is a technique for the optimization of a linear objective function subject to linear equality and linear inequality constraints. The method of linear programming is also known as the method of linear optimization. Further, this method was employed to achieve the best outcome, for example, the maximum profit or the lowest cost, in a mathematical model whose requirements are expressed in the form of linear relationships. This method was employed to maximize the profit function of the farming enterprises in the proposed research.

Linear programming technique was chosen because this is one of the most powerful and efficient tools of analysis among the various analytical tools available for allocation of available limited farm resources among alternative enterprises. The model is set up to maximize sum of net value of production (net returns) of small ruminants' enterprise, subject to number of constraints on various food and non-food variables. Mathematically, the problem is stated as follows:

Maximize:

$$Z = \sum_{j=1}^{n} C_j X_j$$

Subjected to constraints

$$\sum_{i=1}^{m} a_{ij} x_j \leq b_i,\ i = 1, 2, ...,m$$

$$x_j \geq 0,\ j = 1, 2, ...,n$$

Where;

Z = Net returns from all small ruminants' activities in the model.

C_j = Per small ruminants per day net returns from the jth activity.

X_j = The level of jth activity providing c_j returns per small ruminants per day.

a_{ij} = The per small ruminants per day amount of the ith resource required in jth activity, also known as the technical or input-output coefficients.

bi = The amount of i_{th} resource available to the farmer for the activity x_j. where, i = 1,2,....., m.

j = 1, 2,... n, number of variables.

i = 1, 2,... m, number of constraints.

One of the most important components of the linear programming model is the identification of resource limitations. In this context, the following two types of constraint was designed for the same.

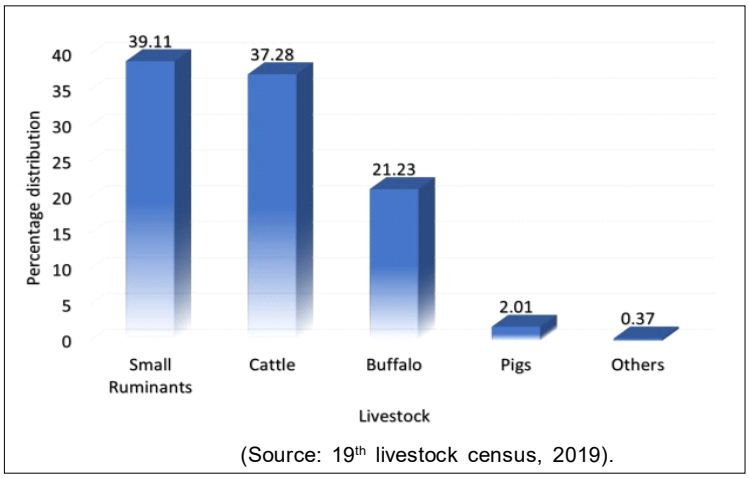
Family labour was calculated on the basis of the number of the family members that were actually in the process of the working. This restrictions with regard to the family labour were imposed for all the different types of small ruminants.

For the availability of capital/input in small ruminants' enterprise, the constraint was set up in such a way that the cost in a particular year is to be fulfilled by the net returns from the previous year.

Lindo software was used for running the linear programming (simplex) model.

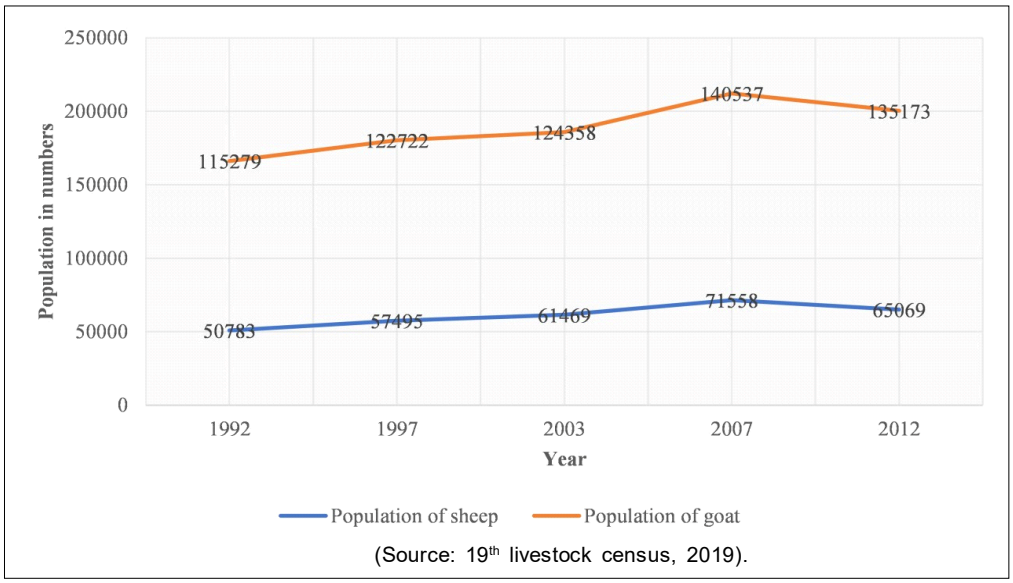
RESULTS AND DISCUSSION

Small ruminants found out to be remunerative for the farmers in the rainfed regions of Jammu division. If we consider Kathua district, total cost worked out to be Rs. 43.02 per ruminant per day, whereby, labour forms the major component. Gross returns were found out to be Rs. 51.93 per ruminant per day (Table 1). In case of Udhampur district, total cost per ruminant per day was revealed out to be Rs. 44.11. Labour is still the dominant cost component here. Shifting our focus now to district Rajouri, we can observe that the gross returns in this district found a place in the midway *i.e.*, higher than Udhampur and lower than that of Kathua, respectively and labour is still the dominant cost component in this district. Thus, labour came out to be the dominant component in the cost structure in rearing of small enterprise. On the returns side, there was not a single dominant factor. Rather, the position of dominance was found oscillating between sale of mutton and sale of small ruminants, respectively. In case of Kathua district, sale of mutton was revealed out to be the major component (about 49 percent). Similarly, sale of mutton was also found out to be the dominant revenue generating source for the farmers in Udhampur district, where it forms about 42 per cent in the composition of gross returns, respectively. The high share of 'sale of mutton' in Kathua district is attributed to the better marketing facilities prevalent in this district. Moreover, blocks like *Dinga Amb* were found not to be very far of from the main city, thereby, opening new vistas for farmers in mutton business. If we consider the case of Rajouri now, 'sale of small ruminants' comprised up of the major share in the total returns for the farmers. It comprised up of about 41 per cent of the total returns. It is to be asserted here the fact, that, small ruminants were observed to be used as the source for meeting the immediate case needs of the farmers in the districts as small ruminants had found



(Source: 19th livestock census, 2019).

Fig 1: Percentage distribution of small ruminants (sheep and goats) in comparison to other livestock.



(Source: 19th livestock census, 2019).

Fig 2: Population of sheep (indigenous) over the years 1990-2012.

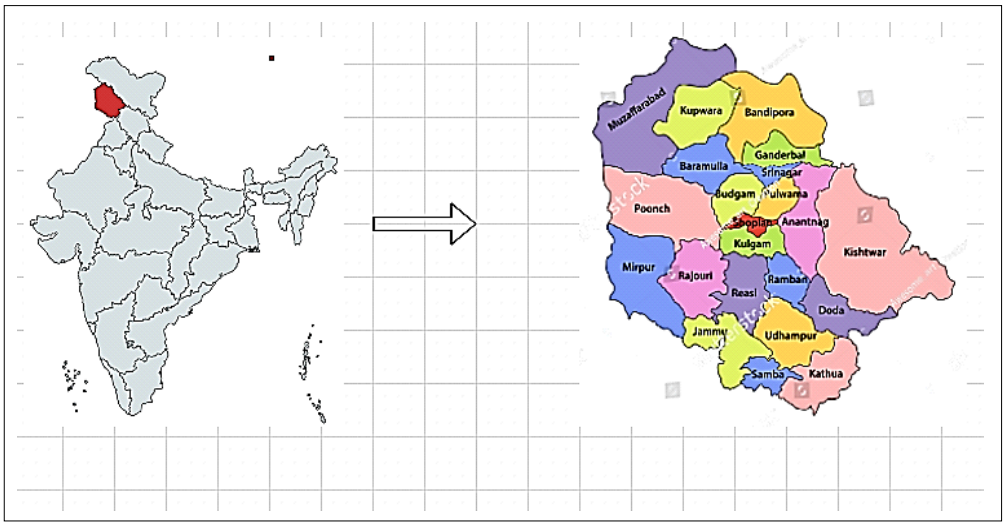


Fig 3: Diagram representing the study area in India.

to have high liquidity in comparison to other assets that farmers were in possession of. Small ruminants were found to be used as the source of financial security (Oluwatayo *et al*., 2012, Wodajo *et al*., 2020, Alhaji *et al*., 2013). Net returns were found to be high in case of Rajouri district. Therefore, it becomes imperative that use of small ruminants as a highly liquid assets should be propagated so that the positive outcome out of it could be generated.

Productivity of input-use

The resource-use efficiency of small ruminants has been represented in Table 2. By carefully analysing the table, it can be observed in Kathua district that input 'concentrates' worked out to be positively significant *i.e*., 0.22. It signifies the fact that one unit increase in the cost of 0.22 per cent in returns for the farmer. As revealed by MVP, this input was being under-utilized and therefore, there was high scope of increasing the application of this input. While preparing feed, there is immense need of underscoring the need of utilisation of hay and cereal straw materials, as its importance not only restricted to that of the nutritional requirement but also to that of the cost- effectiveness (Marín *et al*., 2010). In addition, labour and medicine and veterinary care found out to be negatively related. Further, 0.14, 0.42 and 0.58 found out to be the value of regression coefficients of dry fodder, green fodder and miscellaneous. Green fodder was found out to be under-utilised in this district, which is contrary to some research findings in Rajasthan where this input was turned out to be over-utilized (Meena *et al*., 2012). It can be observed from the table that there was high scope of increasing the inputs of green fodder and miscellaneous items so as to increase the income of the farmers.

In case of Udhampur, the production process of small ruminants reflected 98.75 variability in dependent variable on account of the independent variables. In this district,

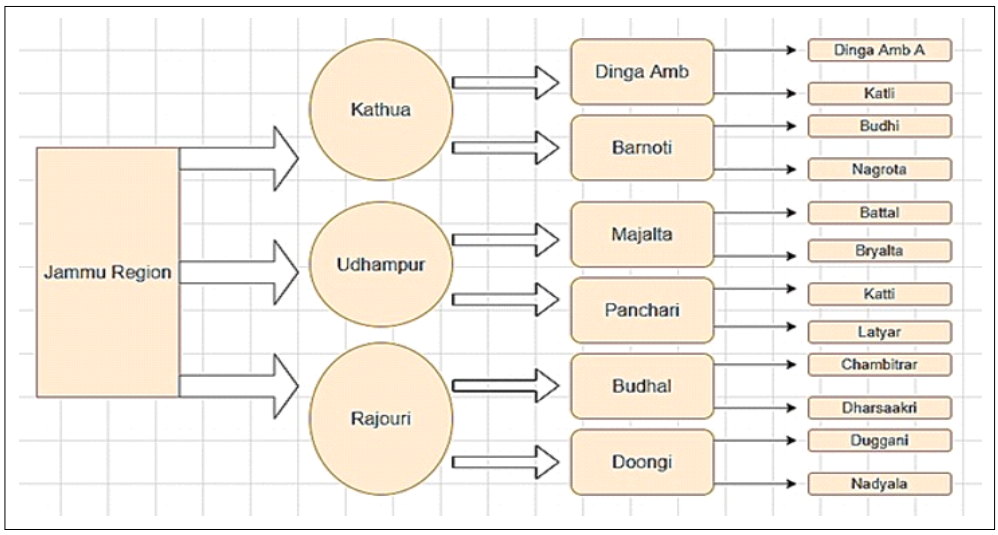


Fig 4: Flow chart representing the designated sampled area of the study.

Table 1: Economics of small ruminants under rainfed conditions*.

Particulars	Kathua (Per ruminant per day)	Udhampur (Per ruminant per day)	Rajouri (Per ruminant per day)
Costs			
a) Dry fodder	9.07	8.07	6.06
b) Green Fodder/grazing	8.31	6.58	5.48
c) Concentrates	2.43	1.56	2.46
d) Labour	20.36	15.87	17.17
e) Medicine and veterinary care	1.65	1.56	2.16
f) Miscellaneous	1.2	1.54	1.24
Total cost	43.02	35.18	34.57
Returns			
a) Goat milk	12.45	10.45	8.15
b) Manure	3.45	2.73	2.33
e) Sale of small ruminants	10.54	12.44	19.45
f) Sale of mutton	25.49	18.49	17.43
Gross returns	51.93	44.11	47.36
Net returns	8.91	8.93	12.79

Table 2: Resource-use efficiency of small ruminants by using Cobb-Douglas production function.

Variables	Kathua		Udhampur		Rajouri	
	Coefficients	MVP	Coefficients	MVP	Coefficients	MVP
Constant or intercept	3.702 (1.351)		-5.248 (8.649)		3.342 (0.078)	
X_1 Dry fodder	0.141 (0.518)	0.852	1.184 (1.450)	5.439	0.033 (0.052)	0.262
X_2 Green fodder	0.422 (0.329)	2.953	-1.125 (2.021)	-7.571	0.043 (0.033)	0.377
X_3 Concentrates	0.219* (0.029)	4.232	-1.581 (2.394)	-40.683	0.038 (0.027)	0.761
X_4 Labour	-0.395 (0.532)	-1.018	3.559* (1.560)	9.878	0.057 (0.049)	0.163
X_5 Medicine and veterinary care	-0.008 (0.063)	-0.434	-0.471 (5.352)	-10.705	0.025 (0.018)	0.605
X_6 Miscellaneous	0.577 (0.392)	24.555	-0.565 (6.832)	-17.304	0.809* (0.030)	30.959
R^2 %	99.49		98.75		99.98	
Σbi	0.955		1.00		1.004	

*Significant at 5 per cent level of significance.

(Figures in parentheses show standard error).

Table 3: Linear programming output summary for agricultural-allied enterprises under rainfed conditions in four districts.

Small ruminants		Unit (per animal per day)	Kathua	Udhampur	Rajouri
Cash outlay	Optimum	Rs.	32.54	39.74	40.49
	Existing	Rs.	43.02	35.18	34.57
Labour requirements	Optimum	Man days	1.50	1.72	1.12
	Existing	Man days	2.17	1.30	0.87

labour found out to be positively significant (at 5 per cent level). This is supported by studies in Rajasthan (Smita and Rawat, 1999). One unit increment in the cost would tend to enhance the returns for the farmer by 3.56 per cent. Therefore, this input was highly important in this district. Also, there was high scope of increasing the utilisation of this input as this was being under-utilized. Another positive coefficient was found out to be dry fodder (1.18). Rest of the coefficients yielded negative results and therefore, their application needs to be contained for the benefit of the farmers.

Constant returns to scale were again being observed in case of Rajouri district. 99.98 per cent variation in gross returns were explained by the six independent variables. Cost in the miscellaneous variable needs to be enhanced as they were found under-utilized. Rest of the variables showed over-utilization of the resources and therefore, there was not much scope of increasing the same, though, the increase in the cost of these variables would tend to increase the returns for the farmer by 0.03 per cent, 0.04 per cent, 0.04 per cent, 0.06 per cent and 0.03 per cent in case of dry fodder, green fodder, concentrates, labour and medicine and veterinary care, respectively. The resource-use-efficiency analysis revealed that there is the need of enhancement of the input use management in the small ruminants and this has been corroborated from the past studies (Diogo *et al*., 2010).

Optimisation of input-usage

Past studies (Almeida, 2017) on the application of linear programming deals with the credit needs (de Medeiros *et al*., 2009), adjustment in the fat milk contents (Habtegebriel and Admassu, 2016), *etc*. but there was indeed a void in the application of linear programming in optimisation in terms of cash outlay and labour requirements.

Small ruminants played more important role in Udhampur and Rajouri districts, therefore, it is not uncommon to reveal the fact that the cash outlay in these two districts needs to be enhanced in comparison to that of Kathua district. In case of labour requirements, there is need of curtailing the application of labour in case of Kathua district (Table 3) and at the same time, there is need to aggravate the application of labour in case of rest of the two districts, respectively. In Rajouri district, there is huge scope of increasing the labour in this enterprise as small ruminants are more suitable for the difficult and mountainous terrains. A study in Switzerland clearly emphasised the importance and relevance of sheep and goat in the mountain regions in terms of conserving biodiversity (Aepli and Finger, 2013). Here, it turns out to be very imperative that increasing the labour does not only amount to the adding up of the more labour as an individual unit, rather, the focus should be primarily on enhancing the productivity of labour in these regions. Table 2 clearly depicts that in the Rajouri district, labour is over-utilized. Therefore, significance lies here in increasing the productivity of labour rather than in increasing the number of man days in labour per se.

CONCLUSION

Small ruminants played an important role for the farmers in the rainfed regions of Jammu division. Because of the advantages like hard and sturdiness, easy selling for cash requirement, among others, small ruminants turned out to be indispensable for the mountainous regions. While analysing the economics of this enterprise in Kathua,

Udhampur and Rajouri districts, total cost was revealed to be high in comparison to the rest of the two districts. This enterprise found out to be highly profitable in the Rajouri district, whereby, sale of small ruminants formed the major component. Milk of goat did not comprise up of the larger component in the total net returns from the enterprise, signifying the fact that the goat milk is relatively less popular in these regions. Under-utilization of the green fodder and concentrates were observed in the case of Kathua district. Under-utilization was also observed in the inputs dry fodder and labour in case of Udhampur district. Almost all variables/inputs were found out to be over-utilized in case of Rajouri district, respectively. Linear programming output summary disclosed the fact that there were wide variations in the optimum and existing utilisation of the resources (cash outlay and labour requirements) in all the three districts. This gap could be curtailed with appropriate measures like training of labour engaged in this enterprise so as to enhance their productivity that will inexorably lead to the high remunerative income for the farmers in the rainfed regions. In the end, it can be concluded that it becomes pertinent rather indispensable to utilise small ruminants' enterprise in the rainfed regions of Jammu, in particular and in South Asia, in general.

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Conflict of interest

All authors declare that they have no conflict of interest.

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