CONSTRAINING RESOURCES PREVENTING THE OPTIMAL PROFITABILITY BY GOAT RAISERS IN CAMEROON

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ABSTRACT

Cameroon is on the way to render its pastoral sector more productive by 2035 through the alleviation of the main problems faced by breeders. Because of the interest of most breeders to raise goat, this paper evaluates the constraints faced by goat raisers in the Centre region of Cameroon. From the field results, land and labour are available in sufficient quantity for goat raising activity. Their zero marginal productivity testify that these two resources are not exhausted/non-scarce in comparison to the five other constraining factors (credit, capital, transport to markets, health and food) which are exhausted/scarce hence displaying non-zero marginal productivities in linear programming model. In conclusion, if the government aims at improving the farmers' returns, then resources with the highest marginal productivities should be allocated in priority to goat raisers i.e. credit at first, followed in order by capital, transport to markets, health, food, land and labour. Concrete governmental actions would be the creation of agricultural banks necessary to grant credit or capital facilities to breeders, veterinary hospitals and centers for training personnel to prevent illnesses and vaccination of goats, to develop road infrastructures and marketing channels for goat activity, to provide goat raisers with quality and sufficient food for their animals.

KEY WORDS

Goat raisers, gross margin, linear programming, marginal productivity.

The agricultural sector, which includes the food and cash crops, livestock and fishery, is considered as the mainstay of the Cameroon's economy. It employs 70% of the population, provides 25% of country's foreign currency and brings about 15 to 20% of the State revenue/returns. During the previous decades, the livestock sub-sector employed 30% of rural people, contributed to about 2.1% of the country's GDP and 30% of the revenue earned by the rural population (Ministry of Livestock, 2018).

The livestock sector is particularly important because it provides products of several categories such as cattle, sheep, goats, pigs and poultry which contribute to sustain the food-self sufficiency and the healthiness of the population of the country and the surrounding CEMAC[1] zone (FAO, 2010; Tsafack, 2016; Jaza et al., 2018). For this reason, livestock keeping is nowadays taken into consideration in Cameroon because of its role and importance in the socio-economic life of poor households and is more and more developed by households to ensure food security and to generate revenue (Upton, 2004; Rooyen and Homann, 2007; FAO, 2012). Hence, the livestock numbers have been at steady increase since 1988 and livestock products are mainly consumed domestically in form of milk and dairy products, meat, eggs and table birds (Tchotsoua and Gonne, 2009; Ministry of Livestock, 2018).

In Cameroon, breeders carried on a particular attention on goat because of its easiest adaptability and low cost of investment (ILCA, 2005; Tsafack, 2016; Jaza et al., 2018). Also, goat meat constitutes an alternative source of protein supply (FAO, 2010). Despite these characteristics and the number that are reared (3.8 million of goats in 2015), Cameroon

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[1]CEMAC=Communauté Economique et Monétaire d'Afrique Centrale (Central Africa Economic and Monetary Community).

appeals to high imports of goat products. This is to face problems of scarcity and rising prices of goat products due to the increase of the country's population and urbanisation. Inversely, Cameroon's exportation of goat products is very slight and restricted to neighbouring countries (Tsafack, 2016; Jaza et al., 2018). As a matter of fact, the current goat production of the country is unable to satisfy the national demand and exports because the goat activity knows serious problems (Ministry of Livestock, 2018). Although owners appreciate goats for their multiple functions, they invest little in management technologies that would secure goats' survival in dry seasons or even to achieve higher performance of their herds and as a result, goat productivity remains low and farmers have fewer goats available for use (Rooyen and Homann, 2007; Tsafack, 2016; Jaza et al., 2018).

In sum, the low goat productivity arises from the multiple constraints faced by breeders engaged in the goat raising sector. Among them, we can cite the low labour productivity, a limited number of market-oriented enterprises, the traditional or archaic system of breeding animal, the low capital or limited access to credit for investment, the limited number of infrastructures for collecting, processing, storage and marketing of goat products, the low organization of the market of goat products, the low diseases control in goat production, the low respect of law, regulation and norms in goat production, the low training of goat raisers, etc (Upton, 2004; ILCA, 2005; Rooyen and Homann, 2007; Tchotsoua and Gonne, 2009; FAO, 2010; FAO, 2012; Jaza et al., 2018; Tsafack, 2016; Ministry of Livestock, 2018). Nevertheless, the national production of the goat activity could be improved if some of these constraints are alleviated (Tchotsoua and Gonne, 2009; Ministry of Livestock, 2018).

The government is aware of these constraints and has elaborated a Strategic Document for Growth and Employment in order to enable the country to become emergent by the year 2035. The livestock and goat raising sector is of particular importance in that document so as to face the above named constraints of the sector. In order to follow up the implementation of this challenge, the goat project was launched in 2013 in the country in order to exploit genetic characteristics of goats, improve productivity and generate revenue. As the constraints faced by goat raisers are numerous and in order to enable the project or decision makers to tackle the main constraining ones, this study was undertaken so as to highlight and assess the extent of each constraint on the farmer's returns. More specifically, the study seeks to evaluate the main resources needed by goat raisers in order to improve their gross margin.

MATERIALS AND METHODS OF RESEARCH

The field survey was carried out from 1ˢᵗ April to 30ᵗʰ June 2016 in the Centre region of Cameroon. The following six divisions of the region were surveyed: Mfoundi, Haute-Sanaga, Mefou-Afamba, Mefou-Akono, Mbam-et-Kim and Lekié. These divisions were chosen in order to benefit from the facility offered by the goat project implemented in these areas since 2013. Furthermore, the survey intended to help the goat project to build up a strong database by collecting information on goats in the Centre region.

At each division, 26 to 27 goat raisers were selected so as to survey a total of 160 farmers throughout the whole study area. The selected goat raisers were farmers practicing the goat raising as main activity during the previous two to three years (since the launch of the goat project in 2013). Using a structured questionnaire and interview-schedule, cross-sectional primary data of the calendar year 2015/2016 were collected from the selected farmers. Based on the literature review of the constraining factors to goat raising activity, the data collected from each farmer were the goat herd/flock size, the fodder production, the availabilities of land, labour, capital and credit limit, the health and food expenses, the land use for fodder production and goat raising activity, the cost, revenue and gross margin gained from goat raising activity, etc.

In order to achieve the study objective, a linear programming (LP) technique is more convenient to complement the descriptive statistics arising from field survey. According to Hazell and Norton (1986), a linear programming model requires a specification of the farm activities, resources constraints and the forecasted gross margin (GM) (Hazell and Norton,

1986). As the study assumes that fodder is solely planted for goat nutrition, we need to know the farm size to be used for planting fodder (for feeding goat) and the number of goats to be raised by each breeder so as to maximize his gross margin (GM), and given the constraints of available resources of land, labour, capital, credit limit, health costs, food expenses, and transport to market costs. Hence, the activities which enter into the programming model are the number of hectare of fodder to produce (X_1), the number of goat to raise (X_2) and the amount (in FCFA) of credit to borrow for raising goat (X_3). The problem is summarized in the linear programming tableau of Table A.1 in Appendix.

The Right Hand Side (RHS) includes data on the farmer's yearly resource availabilities according to the field survey data. These are 7.68 ha of land, 8,064 mandays of labour, 102,688 FCFA of capital, 34,235 FCFA as health expenses, 79,000 FCFA for feeding cost, and 11,800 FCFA for transport cost to markets. Besides, the study considers that, the production of 1 ha of fodder requires 600 mandays of labour and 50,000 FCFA of capital. Likewise, the breeding of one goat requires 0.15 ha of land, 750 mandays of labour, 60,000 FCFA of capital, 20,000 FCFA for health expenses, 30,000 FCFA for feeding cost and 1500 FCFA of transport to markets' cost. The forecasted gross margins (GM) of activities are: 30,000 per hectare of fodder produced and 50,000 FCFA per goat raised. Additionally according to the field reality, some breeders are members of common initiative groups/local banks where they can borrow money to sustain their goat raising activities at an annual interest rate of 18% and the maximum credit amount is generally limited to 88,667 FCFA per year.

The detailed mathematical equations of the linear programming model for this study are:

Objective function:

$$\text{Max GM}=30{,}000X_1+50{,}000X_2-0.18X_3 \qquad (1)$$

Subject to the constraints:

$$1X_1+0.15X_2+0X_3\le 7.68 \text{ [Land availability]} \qquad (2)$$

$$600X_1+750X_2+0X_3\le 8{,}064 \text{ [Labour availability]} \qquad (3)$$

$$50{,}000X_1+60{,}000X_2-1X_3 \le 102{,}688 \text{ [Capital availability]} \qquad (4)$$

$$0X_1+0X_2+1X_3 \le 88{,}667 \text{ [Credit limit]} \qquad (5)$$

$$0X_1+20{,}000X_2+0X_3\le 34{,}235 \text{ [Health]} \qquad (6)$$

$$0X_1+30{,}000X_2+0X_3\le 79{,}000 \text{ [Feeding]} \qquad (7)$$

$$0X_1+1500X_2+0X_3\le 11{,}800 \text{ [Transport to markets]} \qquad (8)$$

The set of equations (1) to (8) were subsequently integrated into the GAMS (*General Algebric Modeling System*) software for resolution. The GAMS software was mainly used to estimate the endogenous or decision variables from the linear programming model which are: Max GM: maximum gross margin (FCFA); X_1: Fodder area (ha); X_2: Goat number (n°); X_3: credit borrowed (FCFA); and the marginal productivities (shadow prices) of land, labour, capital, credit limit, health expenses, food cost and transport to markets' cost.

RESULTS OF STUDY

Table 1 presents the flock size from selected goat raisers in the study area. The flock size is the number of goats owned permanently by herders at any period of the year. On average, the goat raisers from the Centre region own permanently 34 goats per year. The large standard deviation of 52 indicates the wide variation of the flock size from one goat

raiser to another. The highest number of animals owned by any goat raiser is 300 goats while the smallest herd owned by any breeder is 2 goats. As fodder is the main food to raise goat in the Centre region, the goat raisers tend to produce it to supplement various food eaten by goats during their divagation. In the study area, the fodder production ranges from 8 to 38 tons/ha with an average of 22.7 tons/ha.

Table 1 – Goat flock size and fodder production per farmer in the Centre region (N=160)

n/n	Min	Max	Mean	Standard Deviation
Goat flock size (number)	2	300	33.9	52.7
Fodder production (tons/ha)	8	38	22.7	7.63

Resource description: availability of land, labour, capital, credit, health, food and transport to markets' money to raise goat.

Table 2 testifies that every goat raiser in the study area (Centre region) owns a parcel of land which is used either for ranching or fodder production. The ranching land is generally an open space where goats could freely divagate in order to find pasture or any other ingredient to eat in the nature. Since the surveyed areas are less populated (24 inhabitants/km²) as compared to the overcrowded Yaoundé-city where the population density is very high (3,802 inhabitants/km²), the mean land availability of 7.68 ha (Table 2) owned by goat raiser is justified. This is relatively high as compared to the average size of agricultural exploitation of 1.8 ha per farmer in the whole country, 1.61 ha in the Centre region and 0.61 ha in the Yaoundé urban and peri-urban area (Jaza, 2005).

The labour availability is high in the study area as testified by the minimum figures (every farmer has at least 3,028 mandays of annual labour) (Table 2). The high unemployment rate in Cameroon (about 30%) associated to the very high in-labour migration of the population into the Centre region (which owns Yaoundé, the capital city of Cameroon) is a good justification for these figures. However, this high labour availability is a great advantage to the goat raisers as active labour hand is needed to tie, graze, hunt, chase away, displace or carry out the goats from one place to another, depending on the necessity (Jaza et al., 2018). But generally in the study area, most goat raisers use mainly familial/unskilled labour with occasional recruitment of hired/skilled labour to take care of their goats when diseases occur or at the peak moment of vaccination of their goats.

Table 2 – Resource availability per goat raiser in the Centre region (in unit per year) (N=160)

n/n	Min	Max	Mean	Standard Deviation
Land (ha)	0.02	100	7.68	13.8
Labour (manday)	3,028	19,580	8,064	6,345
Capital (FCFA)	25,000	500,000	102,688	53,143
Credit (FCFA)	0	200,000	88,667	5,335
Health expenses (FCFA)	0	56,350	34,235	2,455
Food costs (FCFA)	35,000	200,000	79,000	19,220
Transport to markets' cost (FCFA)	600	30,000	11,800	5,300

As Table 2 shows, the capital used by goat raisers ranges from 25,000 to 500,000 FCFA with an average of 102,688 FCFA. The low capital investment testifies that money is a constraining factor to the goat raising activity as it would be analysed in the next section of the linear programming model. Since the goat raisers lack enough capital amount for undertaking their activity, credit appears as a supplement to capital and the amount of credit contacted by breeders to sustain their activity averaged 88,667 FCFA. However, some farmers do not use credit (minimum=0) while the maximum credit borrowed by any farmer is 200,000 FCFA (Table 2).

As regards to the health expenses (Table 2), the minimum is zero probably because most farmers raise their goat in archaic conditions lacking money for paying medicines to treat or vaccinate their goat against diseases. Only a few farmers could afford to take care of their goats (at maximum health care expenses by following the vaccination calendar. However, with the arrival of the goat project in the study area, we expected that most

breeders would pay attention to the health of their goats because they would receive further advices and even occasional support/subsidy to take care or vaccinate their goats.

The food expenses range from 35,000 to 200,000 FCFA with an average of 79,000 FCFA per year. This small range of food expenses is justified by the field reality according to which, only a few goat raisers cultivate the fodder to raise their goat. Most breeders choose the free of charge option which consists to leave their goats in divagation in the nature where every goat would try alone to feed itself. This divagation practice is economic to goat raisers who save much of the money they would have used to buy food for feeding their goats.

As Table 2 shows, an average of 11,800 FCFA is spent per goat raiser every year for transporting their goats to the markets. This small amount could be justified by the fact that, most breeders are discouraged by the bad state of roads for transporting theirs goats to the markets. As roads are dusty in dry seasons and muddy in rainy seasons, the breeders prefer to liquidate their goats to other neighboring farmers or rather sell their goats to small markets at the vicinity of their exploitations where they do not need to pay high transport costs.

As the baseline linear programming (LP) model results nearly reflected the field reality, the model was validated (Hazell and Norton, 1986). Hence, this section presents the baseline LP model results for the activities and resources necessary to solve the problem.

The baseline LP model results show that with 7.68 ha of land availability owned on average by any goat raiser in the study area, 22% of this land area (1.69 ha) is used for fodder production, 63% (32.3x0.15=4.84 ha) of it is used as divagation plot[2] for goats while the remaining parcel (7.68 ha *minus* 1.69 ha *minus* 4.84 ha =1.15 ha) representing 15% of the whole area is left on fallow/unused. The computed flock size (32.3 goats) is nearly similar to the number of goats owned permanently by farmers in the field (33.9 goats), thereby testifying the validity of the LP model results.

Table 3 – Optimal land used for each goat raiser (from 7.68 ha of land owned on average per goat raiser)

Plot types	Optimal solution		Marginal productivity of plot
	Number of goats in plot	Used land area in hectares (% land used in brackets)	
Plot for divagation of goats (ha)	32.3	4.84 (63%)	0
Plot for fodder production (ha)	0	1.69 (22%)	0
Plot in fallow/unused land (ha)	0	1.15 (15%)	0
Total	32.3	7.68 (100%)	0

Notes:
-One goat requires 0.15 ha of land i.e. 4.84 ha for 32.3 goats.
-The gross margin earned by goat raiser is: 122,820 FCFA per year.

Table 3 displayed zero marginal productivity for all plots' types which explains that, land is available in sufficient amount so as to maximize the farmer's gross margin. Hence, a goat raiser does not need supplementary plot type since any increase of land use would not change its gross margin (Hazell and Norton, 1986). The optimal gross margin earned by goat raiser by considering the three utilizations of land (plot for divagation of goats, plot for fodder production, plot in fallow/unused land) is on average 122,820 FCFA per year.

Table 4 shows that there exist scarce and non-scarce resources for goat raising activity in the study area. By definition, scarce resources are fully used up or exhausted during the production process whereas non-scarce resources are not completely used up, thus leaving a remaining quantity at the end of the production process (Debertin, 1986; Doll and Orazem,1978).

According to Hazell and Norton (1986), the scarce resources are those whose marginal productivities are greater than zero whereas the non-scarce resources are those whose marginal productivities are equal to zero (Hazell and Norton 1986). In general, the higher the marginal productivity of a resource, then the scarcer is that resource (Hazell and Norton,

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[2]The breeding of one goat requires 0.15 ha of land i.e. 4.84 ha for 32.3 goats.

1986; Jaza, 2005). Hence, scarce resources by order of rarity in this paper include credit, capital, and transport to markets' cost, health expenses and food expenses (Table 4). For these resources, the goat raiser must increase their use in his activity if he would like to further increase his gross margin. But resources whose marginal productivities are zero are non-scarce resources (including land and labour) to goat raisers because any increase in their amount of utilization would not change the gross margin. Hence, for these resources, the goat raisers must scrupulously respect the quantities recommended by the model.

Table 4 – Recommendations of the model and marginal productivities of resources used for the goat raising activity

Resources	Available quantity (upper limit)	Recommended amount (optimal solution)	Marginal productivity	
			Value	Rank
Land (ha)	7.680	6.528	0	6th ex
Labour (manday)	8,064	2,348	0	6th ex
Capital (FCFA)	102,690	102,690	2.65	2nd
Credit (FCFA)	88,667	88,667	2.87	1st
Health expenses (FCFA)	34,235	34,235	1.70	4th
Food expenses (FCFA)	79,000	51,353	1.40	5th
Transport to markets' cost (FCFA)	11,800	11,800	2.20	3rd

Results from the previous section already show that (Table 3), out of the 7.68 ha of land owned by the goat raisers, 1.69 ha (22%) is used for fodder and 4.84 ha (63%) is used as parcel for goat divagation, making a total land use at 6.53 ha. Hence, the land is not exhausted since an amount of 7.68 *minus* 6.53=1.15 ha (15%) remains unused. The zero marginal productivity of land confirms its non-exhaustion and suggests that, if one more hectare of land is available, the gross margin of goat raiser would remain the same.

The same interpretation could be made to the zero marginal productivity of labour explained by the non-exhaustion of this resource. Probably the high in-labour migration and unemployment rate around the Centre region of the country could justify why labour is not fully used (zero marginal productivity): out of 8,064 mandays available, only 2,348 mandays (29.12%) of it is used to solve the problem (Table 4). This testifies the low labour productivity which was already highlighted among the constraints faced by breeders of this sector. As most farmers are not trained, the labour provided is mainly unskilled labour leading to lower productivity.

In Table 4 results, resources were classified by order of priority in function of the value of their computed marginal productivities. From that ranking, the scarce resources occupy the top positions among the goat raising constraints to be alleviated in priority whereas the non-scarce resources such as land and labour occupy the bottom positions because of their zero values marginal productivities. With its highest marginal productivity (Table 4), credit is the 1st most constraining factor to the goat raising activity in the study area. The credit is exhausted as the 88,667 FCFA amount of borrowed money is fully used. The non-zero marginal productivity of credit (valued at 2.87 FCFA) testifies this exhaustion and is a proof that credit is a very important resource to improve the gross margin of goat raisers. The economic interpretation is that, any 1 FCFA increase in credit borrowed by goat raiser would improve the gross margin by 2.87 FCFA. This is not a surprising result as a previous study by Jaza (2018) in the same area found that, credit opportunities are rare and only 8.12% of goat raisers used credit for financing their activities in that region. Hence, credit should be treated as an important constraint which prevents the goat raising activity in the Centre region of Cameroon.

The capital is however exhausted (the totality of 102,690 FCFA is used); hence the model displays a marginal productivity of 2.65 FCFA for this resource. Thus, capital is the 2nd most constraining factor as regards to its position among all other production factors. This might be attributed to the poor living conditions of these goat raisers. The computed shadow price of capital indicates that, any additional 1 FCFA of capital granted to these goat raisers would increase 2.87 FCFA in their gross margin because such amount could help them to purchase more productive inputs (food, health/vaccination expenses, housing, etc) (Table 3).

The transport to markets' cost is also exhausted i.e. the amount of 11,800 FCFA allocated for it is fully used. In Table 4, the 3rd position that the transport to markets' cost occupies among all other production factors is due to the high value of marginal productivity (valued at 2.20 FCFA) of this resource. Hence, if 1 more FCFA of transport to markets' money is made available to farmers, and then the gross margin would increase by the value of 2.20 FCFA.

In Table 4, health expenses appear to be the 4th most constraining factor to the goat raising activity. The computed marginal productivity of health expenses implies that, 1 FCFA amount of money invested in the health of goat would improve the gross margin of goat raiser by an amount of 1.70 FCFA. Similar interpretation is valid to the food expenses' constraint (5th position) where, 1 FCFA amount of money invested in goats' food would increase the gross margin by an amount of 1.40 FCFA.

To sum up according to computed marginal productivities of resources (Table 4), the most constraining factor to the goat raising activity is credit (1st position), followed in order by capital (2nd position), then by transport to markets' cost (3rd position), then by health expenses (4th position), then by food expenses (5th position), and lastly by both the land and labour which display a zero marginal productivity justifying their last positions (Table 4). Hence, apart from land and labour which are not very important resource necessary to improve the gross margin, care should be taken to all other production factors so as to increase the returns of goat raisers.

DISCUSSION OF RESULTS

According to the field reality, every goat raiser owns on average 7.68 ha of land (Table 2) subdivided into three parts: 1.69 ha (22%) as fodder land, 4.84 ha (63%) as goat divagation's land and 1.15 ha (15%) left in fallow (Table 3).

The results of the linear programming (LP) model show the excess of land resource in the study area, as testified by the zero value of land marginal productivity (Table 4). Hence, the goat raisers do not need supplementary land area for their activities. These results are easily understood from a socio-demographic and historical perspective by considering the population density, non-pastoral nature and farm size in the Centre region.

Population density: The Centre region extends over 70,000 km² out of the 475,000 km² of surface area covered by the whole Cameroon i.e. about 14.74% of country's area. Its population density is 24 inhabitants/km² as compared to 60 inhabitants/km² for the whole country. Hence, apart from the crowded Yaoundé capital-city where the population density is very high (3,802 inhabitants/km²), other parts of the Centre region have enough space which could advantageously be valorised by goat raisers to undertake their activity (Jaza, 2005; Tchotsoua and Gonne, 2009; Jaza et al., 2018).

Non-pastoral region: Contrary to the northern part of the country, the Centre region is still a non-pastoral region by nature meaning that this area was not invaded in the past by herders (Tchotsoua and Gonne, 2009). Thus, a lot a free space is still unoccupied and could potentially be valorised for breeding animals. Hence any goat raising activity in open land or divagation system would not face a major difficulty in this zone.

Farm size: The average size of agricultural exploitation is 1.8 ha in Cameroon and 1.61 ha in the Centre region. But the field reality shows an average of 7.68 ha of land owned by goat raisers (Table 2), testifying that those currently engaged in goat raising activity have enough land at their disposal as compared to other farmers of the Centre region and to other producers in the country in general (Jaza, 2005).

From the field survey results, only 29.12% (2,348 out of 8,064 mandays) of the available labour force is currently used for goat raising activity in the study area (Table 2). These findings are confirmed by the LP model results displaying the zero marginal productivity (shadow price) of labour, which indicates the surplus of this resource in the study area (Table 4). The zero labour marginal productivity was already interpreted by showing that any additional labour employed in goat raising activity would not improve the gross margin because the existing available labour was not fully used. In other terms, it would not be

profitable to employ supplementary labour since it is not a scarce resource in the study area. The very high unemployment rate in Cameroon (30% of the total population) and the in-labour migration of the country's population in the search of jobs towards the Centre region which contains the capital city (Yaoundé, also county-town of the Centre region) could justify this excess of labour resource.

Our results are similar to Tsafack findings (2016) according to which, the use of remunerated working hand was negatively correlated to high revenue earned by goat raisers, meaning that, the use of labour implies additional charges for a breeder (Tsafack, 2016). In other words, the employment of salarial workers does not provide enough of outcome in such a way to help a goat raiser to have a high revenue given that the flock size owned is generally small (33.9 goats on average) for goat raisers in the Centre region.

The fact that the labour was not exhausted in the LP model forced us to focus on the low productivity of this resource. The unproductive labour is a consequence of the bad labour quality because goat raisers are unskilled or not trained in most cases. In the field, the employed people to take care of goats are generally recruited among relatives to the family and/or friends who never undertook any technical vocational and educational training (TVET). However, investment on the quality rather than on quantity labour by implementing the TVET education to goat raisers would enable the employment of trained, skilled or productive labourers rather than using large number of unskilled/unproductive labourers as currently observed in the field.

In the study area, respondents reported lack of capital as the major hindrance in improving their business. These are testified by low figure for capital availability (102,690 FCFA per year on average) (Table 2) as well as the high value marginal productivity of capital (2.65 FCFA), which implies that any increase in the capital amount would increase the farm returns (Table 4) These results go with Rooyen and Homann (2007), who found that effort to increase breeders' level of production and introduce improved management systems (e.g. better housing, nutrition and genetic resources) are impeded by the lack of funds to purchase the necessary inputs.

The field survey results already indicate that, the amount of credit granted to goat raisers is very low (88,667 FCFA) (Table 1) and this insufficient credit amount justified its exhaustion in the linear programming model (Table 4). In Table 4, credit is the resource with the highest marginal productivity (2.87 FCFA) proving that it is the scarcest resource to goat raisers. Hence, its 1st position among all other production factors is justified and credit should therefore be treated as the most important constraint which prevents the goat raising activity in the Centre region of Cameroon. Since the goat raising activity requires little investment in management technologies that would secure goats' survival in dry seasons, any use of small credit amount would quickly boost this business in comparison to other livestock or farming activities (Rooyen and Homann, 2007). In the same view, Atieno (2007) demonstrated that, the credit could easily help any breeder to compensate the investment costs spent for its goat raising activity and quickly improve the farm returns.

As a matter of fact, the scarcity of credit in the study area could be justified by the country's economic situation which still suffers from the consequences of economic crisis of the early 1990s. That crisis led to the closure of agricultural bank institutions which granted subsidized credits to farmers. Hence, it would be important for the government to revamp the agricultural finance sector including the creation of agricultural banks which could offer subsidized credit to farmers with a viable project such as goat raising activity.

From the field survey results, the low amount of health expenses (34,235 FCFA per year) spent by goat raisers to their animals testifies the lack of serious they consider while taking care of their animals. Farmers which were surveyed reported the goats' diseases as the main cause of their mortality due to inadequate or lack of veterinary cares. Hence, health is a major constraint faced by goat raiser and this is further testified by the high marginal productivity of health (1.70 FCFA) which also occupies the 4th position occupied among the production factors. Hence, 1 FCFA invested in veterinary cares brought to goats would increase the gross margin by 1.70 FCFA (Table 4).

Previous researches already confirm this assertion. For instance, a study by Mwacharo and Drucker (2005) revealed that diseases are a major constraint to the improvement of the goat industry in the tropics as they decrease production, increase morbidity and mortality, and negatively affect the farmer's returns. These results also go with Mahmoud (2010) findings, who found that disease was a major cause of losses in goat production. Consequently, this makes owner's flock size to decrease in number and to lose in terms of benefit. According to FAO (2010), up to 30% of livestock production in developing countries is lost as a result of disease. A major part of the lack of veterinary care is due to the absence of veterinary officers in the study area, long distance that separates one house to the other and lack of financial means to call for one. Owing to the lack of confidence in the adequacy and continuity of the public animal health services, the producer tends to have less incentive to protect animals through government animal health services as compared with traditional methods (ILCA, 2005).

According to the field reality, the main source of goats' feeding was natural pasture/fodder and crop residues. We already said that every farmers owns a plot size (7.68 ha) containing a subdivided part (1.69 ha i.e. 22%) especially devoted for fodder/pasture production which yields 22.75 tons/ha on average (Tables 1 and 4). As fodder is locally produced to feed the raised goats, the food expenses are valued on average at 79,000 FCFA per year in the study area (Table 2). Furthermore, it was noted that, the production system predominant in the study area is the traditional production system where goats are permanently in divagation to look any food items to eat in the nature. Besides this, there were few goats keepers rearing goats in tying stall housing. Hence, a few goats were fed according to this production system commonly known as stabulation. Thus, the food availability was reported to be one major problem which prevented the goat raisers to adopt divagation rather than stabulation. The choice of divagation rather than stabulation was justified by the difficulty of goat raisers to afford food as testified by the exhaustion of food expenses in the linear programming model (Table 4). The food marginal productivity of 1.40 FCFA implies that the gross margin of goat raiser would be improved if further amount of money is spent for purchasing food for goats.

According to the traditional production system, goats were poorly fed. This is explained by the fact that goats are in constant divagation to look alone for their food what brings someone to say that they are neglected. A study of Mahmoud (2010), confirms that goats are often neglected in comparison with cattle and sheep. So far, the same author shows that part of this attitude towards them can probably be due to recognition of their capability, rather any prejudice against them, as it is believed that goats are intelligent, independent, agile, tolerant to many diseases and parasites and can look after themselves much better than other livestock species. Consequently with this system, goats incur the risk to be stolen. While in stabulation, owners search and bring food to goats. Because of this production system, some goats keepers (especially those in union) developed a system of fodder production on small area where various species of fodder/pasture are planted (*Pennisetum purpureum, Bracaria ruzisiensis*, *Stylosentes*). This helps them to feed goats in rotation during a given period in shed.

However, it would be necessary to consider all systems from feeding the goats in order to avoid the disadvantages of divagation and stabulation which vary from one season to another. For instance, although the system of divagation is cheap to goat raisers, it is however difficult because of the long duration of dry season (four months i.e. from November to February) in the study area, which renders the fodder/pasture to become more scarce and the exercise of feeding animal very difficult. Hence, practicing divagation in rainy season and stabulation in dry season would enable the goat raiser to better feed their goats at any period of the year.

The field survey results show that, on average 11,800 FCFA are yearly spent by goat raisers as transport to markets' expenses (Table 2). The LP model results recommend the transport to markets as the 3rd most constraining factor for the goat raising activity (Table 4). The same results suggest that any 1 FCFA invested in order to alleviate the transport to markets' constraint would increase the farm returns by an amount of 2.20 FCFA. Hence,

goats' transportation and marketing should be seriously taken into account for implementing the goat raising activity in the study area.

According to FAO (2012), markets are major determinants of livelihoods in modern economies, and improved market access has proved to be a potent catalyst for poverty alleviation in transition economies. But in the study area, reality is different because one can note the inadequacy and scarcity of markets. The markets found in the study area are generally unapproachable due to the poor state of road. This confirms Upton findings (2004), according to which in many rural areas, markets are poorly developed, reflecting the limited infrastructure of roads, railways, general communications and lack of appropriate market institutions. Owing to these and the cost of transport, many goat keepers sell their goats at door steps. The main markets (Yaoundé markets) are supplied by the North and the Centre region of Cameroon. But due to poor road, high cost of transaction and small number of goats supplied by the Centre region, some buyers were rather going to the Far North to supply the market in goats.

CONCLUSION AND RECOMMENDATIONS

Despite the huge number of goats that are reared over the country, the factors constraining the productivity of goat, their systems of production and commercialization has received little attention in research and development endeavors. Hence, this paper studies the extent to which the goat raising activity in the Centre region of Cameroon is affected by various constraints such as the availabilities of land, labour, capital, credit, health, food and transport to markets' expenses. The impact of these production factors on farmers' returns is assessed by using the descriptive and linear programming (LP) model approaches.

According to the field survey results, land and labour are available in sufficient amount to goat raisers. These two resources are not exhausted and display zero marginal productivity in the LP model, testifying their non-scarcity in the study area. However, the non-zero marginal productivities of the five remaining production factors (credit, capital, and transport to markets, health and food) testify the exhaustion or scarcity of these resources to the goat raisers. Economically explained, any additional use of the non-scarce resources (land and labour) would not change the gross margin whereas a supplementary investment in the scarce-resources (credit, capital, and transport to markets, health and food) would improve the farm returns to some extent.

Based on the computed values of the marginal productivities of resources from LP model, if the government would like to alleviate the goat raisers' constraints under its limited means, then priority should be given to the resource with the highest value of marginal productivity. On this basis, credit appears as the most constraining production factor to the goat raising activity hence should be granted to farmers at first position. This is followed in the order by capital, transport to markets, health, food and lastly by both land and labour which are not constraining factors at all. These results are easily explained from the field reality according to which goat owners have little money for investment, lack markets to sell goat or encounter difficult access on existing markets, lack medical care to their animals, raise their goat in divagation, etc.

However, because the goat sector has been recognized as having great potential to contribute to poverty alleviation and improved livelihoods for farmers in Cameroon, the importance of the goat sector from a global perspective needs to be sustained by researchers and government for its development, because most of the goat breeders live in the rural areas and their livelihood depend on the revenue of livestock and agricultural products. Hence, the government should implement policy measures which enable the breeders to have a good mastery of their herds. Examples of such measures are the creation of agricultural bank necessary to grant credit or capital facilities to breeders, the creation of animal medical centers for training personnel to prevent case of illnesses and vaccination of goats, to develop road infrastructure and marketing channels for goat activity, to provide goat raisers with quality and sufficient food for their animals. These measures would help to keep constant the goat supply and satisfy its demand all over the country and CEMAC zone.

APPENDIX

Table – Linear programming tableau of the problem

Decision variables	Fodder area (ha) [X_1]	Goat number (n°) [X_2]	Credit borrowed (FCFA) [X_3]	RHS (Goal)
Objective function (GM in FCFA per unit)	30,000	50,000	-0.18	Maximize
Land (ha)	1	0.15	0	≤7.68
Labour (mandays)	600	750	0	≤8,064
Capital (FCFA)	50,000	60,000	-1	≤102,688
Credit limit (FCFA)	0	0	1	≤88,667
Health (FCFA)	0	20,000	0	≤34,235
Feeding (FCFA)	0	30,000	0	≤79,000
Transport to markets (FCFA)	0	1500	0	≤11,800

Notes: GM=Gross Margin; RHS=Right Hand Side.
Source: Prepared according to Hazell and Norton (1986).

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