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Kaposvár University, Faculty of Economic Science, Kaposvár

THE EFFECT OF RANGELAND QUALITY ON THE MINIMUM VIABLE FARM SIZE: THE CASE OF ERZURUM PROVINCE

Abdurrahman KARA[1], Semiha KIZILOGLU[2]
[1]Eastern Anatolia Agricultural Research Institute
[2]Department of Agricultural Economics, Turkey
abdurrahman_kara@hotmail.com

ABSTRACT

The aim of this study was to investigate the effect of rangeland quality on minimum viable farm size (MVFS) in farms dependent on natural rangelands in Erzurum province. Study villages were selected purposely from those for which rangeland quality degrees (RQD) were determined previously. In determination of sample size, stratified sampling method was employed. Study data was taken from the 2004-2005 production year and obtained from face-to-face farmer interviews and reflected in 99 completed questionnaires. In data analysis descriptive statistics were used and linear programming was employed in determination of MVFS. Study villages were grouped under lower, moderate, and upper groups regarding the RQDs and MVFS was calculated for each of rangeland quality group. According to the results, MVFS was calculated to be the farm of 1.9 units of dairy cattle activity and 6.42 ha of farm land. It was also determined that a shift of 16.5% in RQD brought about 0.2 ha of farm size difference in minimum viable farm organizations for dairy cattle farms dependent on natural rangelands. It was concluded that long term and more robust studies with a wider range of variation in rangeland quality were needed to prove the study results since this study was the first of its kind.

Keywords: rangeland quality, dairy cattle, linear programming, minimum viable farm size

INTRODUCTION

Eastern Anatolia region of Turkey is characterized with long and harsh winter conditions. It has the highest elevation, largest area and lowest average mean temperature compared to the rest of the geographical regions in the country. Rugged nature of geography limits the arable land. Moreover, short vegetation period and low temperature restrict the production pattern. However, this part of the country has vast natural grazing lands constituting some 36% in the total. As a result of this, animal production which is the main source of livelihood in most of the region (*Tahtacıoğlu et al.*, 1998; *Kara*, 2000) has been practiced as dependent on the natural rangelands for centuries. Yet, due to insufficient roughage production to fulfill the quality roughage requirements of the farm animals kept inside for about 6 to 7 months, grasslands are grazed as early as the removal of snow cover. Moreover, pastures are in common use and so they are exploited in an opportunistic manner. Each peasant wants to make use of pastures as much as he or she can. So, along with early grazing, overgrazing and high stocking rate are

other problems causing deterioration and loses in herbage production potential of the natural sward communities (*Gökkuş and Koç*, 2001; *Altın et al.*, 2005).

In this region it is necessary to enhance the herbage production capacity of the pastures to a certain level to ensure the nutrient requirements of grazing animals. Although importance and necessity of grazing land improvement studies have gained a common awareness in recent years in Turkey, there is no sufficient quantitative data and information on the contribution of grazing lands to animal production and farm income.

On the other hand, one of the most important problems of the agriculture in Turkey is small farm size and over fragmentation of the farm land (*Demirtaş and Sarı*, 2003). So, farm viability is another important problem (*Vrolijk et al.*, 2010) since it has a direct or indirect effect on the socioeconomic attributes of rural areas. As seen from *Table 1*, about 73% of the total farm holdings have farm size less than 10 ha in Erzurum.

Table 1

Distribution of the farm holdings by farm size in the study area

Farm Size (ha)	Number of Farms	%	Cumulative %
<0.9	3 607	6.831	6.831
1.0-1.9	7 893	14.947	21.777
2.0-4.9	13 811	26.154	47.931
5.0-9.9	13 583	25.722	73.653
10.0-19.9	9 730	18.426	92.079
20.0+	4 183	7.922	100.000
Total	**52 807**	**100.00**	

Source: *TurkStat*, 2001

In order to prevent farm holdings from getting smaller beyond a threshold size, the minimum viable farm size, the Law numbered 3083 namely *"Agrarian Reform Law for Land Regulation in Irrigated Areas"* was legislated in 1984 in addition to the previous land consolidation efforts dating back to 1961 (*Demirtaş and Sarı*, 2003). By this Law and other relevant regulations (*Anonymous*, 2003), land and agrarian reform works were put into action. Parallel to this, the minimum viable farm income has annually been determined by Ministry of Agriculture and Rural Affairs as a duty given by the relevant legislations mentioned above, based on the wholesale price indexes issued by the Turkish Statistical Institute in every July (*Peker*, 1997).

Farm viability is determined by the level of income (*Vrolijk et al.*, 2010) and, of course, the minimum farm size to obtain the minimum viable farm income is to vary from region to region even within the same region because of different ecologic and economic conditions along with the quantity and quality of the production factors. It should be noted that plant and animal production are the agricultural activities completing each other and because of its evident role, land is the principal resource used in agricultural production even though its relative

importance in economic theory has disappeared. Not only for agriculture but also it is still an indispensable necessity for all economic activities (*Metzemakers and Louw*, 2005). So, when agricultural production is the subject of word it ranks first among the production factors affecting farm income.

In this study, the extent of the variation in minimum viable farm size due to grazing land quality was underlined. Thus, the effect of grazing land quality on animal production and farm size was stressed out with a different perspective for guidance to policy makers in their decisions for the sustainability of the grazing land improvement studies ensuring the viability of the rangeland dependent dairy farms in the long run.

MATERIALS AND METHODS

The primary data of the study were collected from the farms with structured questionnaires while relevant official records of Eastern Anatolia Agricultural Research Institute (EAARI) and provincial and district level directorates of agriculture constituted the secondary data.

Study was conducted in the villages of which grassland qualities determined for a previous research work (*Anonymous*, 2006). In total of 582 farm enterprises were put in order from the largest to smallest according to farm size to establish the sampling frame. Sample size was calculated with stratified sampling method (*Çiçek and Erkan*, 1996) at 90% confidence interval with a standard error of 10% of population mean. Strata were determined as 1-12 ha, 12,1-25 ha and 25,1 ha and higher. Data collected through face to face farmer interviews were of 2004-2005 production year and all of 99 questionnaires were evaluated. Rangeland quality degrees of the villages varied between 30,8% and 52,1% (*Table 2*), calculated previously according to the Resource and Environmental Data Interpretation System (REDIS), explained by *Gibson et al.* (1995), using Integrated System for Plant Dynamics (ISPD) software package (*Bosch et al.*, 1992).

Household population was calculated in male labour unit to eliminate the differences arising from age and sex as farm family labour force was calculated in Male Labour Day (*Erkuş and Demirci*, 1996). 10 hours of daily work was assumed (*Karagölge*, 1973; *Hatunoğlu*, 1973). In determination of minimum viable farm size linear programming with minimization procedure was employed (*Bozdağ*, 1976; *Kızıloğlu*, 1989; *Peker*, 1997).

In order to use this method objective should be clearly defined, there should be alternatives to achieve the objective and the restrictions should be taken into consideration (*Karagölge*, 1996).

This method is based upon the assumptions of a) whatever the production scale is, input/output ratio is constant (linearity), b) production factors and products can be expressed with decimal fractions (divisibility), c) each production activity is separate from the others (independency), and d) sources and production factors are limited (limitedness) (*Erkuş and Demirci*, 1996; *Karagölge*, 1996).

In enterprises when the aim is to minimize the costs or as in the present study to determine the production activities to achieve a certain income level (in our

example minimum viable income) objective function is minimized and expressed as in *Formula 1*.

$$Z = \sum_{j=1}^{n} C_i X_i \quad \min, \tag{1}$$

Subject to the constraints

$a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \ldots\ldots\ldots + a_{1n}X_n \geq b_1$

$a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + \ldots\ldots\ldots + a_{2n}X_n \geq b_2$

…

$a_{j1}X_1 + a_{j2}X_2 + a_{j3}X_3 + \ldots\ldots\ldots + a_{jn}X_n \geq b_j$

Where:
Z= Viable income,
C= Gross margin of the unit production activity,
X= Amount of the production activity (number, hectare, etc)
In this method, the relationship between the activities and production factors is shown as *Formula 2*.

$$\sum_{i,j=1}^{n} a_{ij}X_j \leq b_i \quad (\text{i and j} = 1, 2, 3, \ldots. \text{n}) \tag{2}$$

Where:
a_{ij} = technical coefficients (input-output coefficients) between input demand of the activities and production factors,
b_i = limited amounts of the factors used in production (land, labour, etc).

Minimum viable income is determined annually by the Ministry of Agriculture and Rural Affairs according to the written regulations (*Anonymous*, 2003) issued based on the Law numbered 3083 and entitled "Agrarian Reform Law for Land Regulation in Irrigated Areas". In this study was considered 8689 TL as viable income calculated for the period between 01.08.2005–31.07.2006 based on the current legislation (*Anonymous*, 2008). Gross margin is considered in determination of viable income according to the related regulation.

Critical periods for the crop production activities suggested in a previous study (*Anonymous*, 1975) were adapted and four periods were determined according to phenological development stages of main crop groups in the study area.

1. Period (15 March-14 May): ploughing and sowing for summer sown crops.
2. Period (15- May- 31 July): Hoeing and other relevant work in hoe crops, irrigation, first and second cuts in alfalfa, harvest in vetch, meadow cuts.
3. Period (1 August-31 October): Harvest and threshing in cereals and food legumes, third cuts in alfalfa, winter sowing in cereals and vetch, harvest in hoe crops and stubble ploughing.
4. Period (1 November-14 March): No field work.

Labour demands of the production activities and the maximum labour force available in the farms by above given periods were determined according to the

farm data averages. In determination of the days on which field work is not possible daily precipitation was taken into account (*Erkuş and Demirci*, 1996) and mean averages of 30 years between 1975 and 2005 were used for this purpose. Labour force requirements of the second and third periods in which labour demand of the crop production was the highest and total labour force were considered as constraint. Also it was assumed that off-farm labour might be hired in these periods of highest demand. Machine traction power was assumed to be obtained easily through hiring by all farms and not taken as a constraint. Existing stable and sheep fold capacities were also taken as constraint. Operating capital was accepted as variable and operating capital requirements of the production activities were determined.

In the study area under rainfed conditions mainly wheat, barley, vetch and sainfoin were grown and fallow was applied. Rainfall regime of the region makes fallow application necessary (*Anonymous*, 1975) and so fallow land was considered in the plans with current sizes. Under irrigated conditions, on the other hand, wheat, barley, sunflower, sugar beet, potato, alfalfa and vetch are grown. Meadow land, since it is natural vegetation, was considered in plans with actual sizes only were considered the applications towards increasing hay yields. Woodland, vegetable, sunflower and sugar beet were not included in the plans due to their negligible acreages.

In determination of crop rotation limitations the crop acreages and the proportion of the farm land allocated to the crop groups were taken into account. So, cereals were restricted with 67% as wheat and barley were limited with 50 and 25% respectively in this group. Potato as a hoe crop and forage group were restricted with 33%. Similarly, alfalfa and sainfoin were limited with 33% and grain vetch was confined with 67%.

Indigenous cattle breeds and their various crosses made up of the existing large ruminant population in the study area. Dairy cattle is the main animal production activity and fattening is made with young bulls and excess females especially for muslim feast of sacrifice in the study area so only dairy cattle was included in the plans. Dairy cattle activity was measured with production unit (PU) and a PU was calculated for the crossbreed dairy cattle according to farm data mean averages considering the method reported by *Erkuş and Demirci* (1996). Accordingly, one PU for dairy cattle activity consists of 1 head cow, 0.95 head calf, 0.80 head 1st yearling and 0.77 head 2nd yearling. Of the 2nd yearlings 0.20 head is for breeding as 0.57 head is for selling. Similarly PU is also considered in sheep production and one PU was calculated in the light of the farm data and previously conducted study findings in the study area (*Anonymous*, 2009). One PU for sheep production was calculated to be 1 head ewe, 0.05 head ram, 1 head lamb, 0.14 head yearling for breeding of which 0.02 head male. Lambs are sold at the age of 5-6 months at the end of grazing season.

Sale and purchase activities were considered for each of feeds produced in the farm. Crop yields were calculated from the farm data and the prices paid and received by the farmers along with the gross margins were considered in the plans (*Erkuş and Demirci*, 1996). Gross production value of a production activity is

calculated by multiplying its marketable production with its market price. Gross margin is calculated by subtracting variable costs from gross production value (*Erkuş and Demirci*, 1996; *Karagölge*, 1996).

In calculation of the feed requirements of dairy cattle and sheep productions were considered protein, energy, calcium and phosphorus requirements of a PU and the commonly produced feeds in the farms. Farm animals are grazed in permanent pastures from the second week of May to the end of October and no supplement is given during this period in general.

Since the most important nutrient is the energy among the nutrient groups, which is required for maintaining normal metabolism and sustaining a healthy and normal yield level (*Çakır et al.*, 1995), energy requirement is considered as a constraint in the plans and was calculated in total digestible nutrient (TDN). Also, the highest bounds of the feeds in animal diets were taken as constraints to balance the protein and mineral requirements.

On the other hand, it is reported that medium quality pastures could be sufficient for 3-6 kg of daily milk yield in addition to maintenance and yield requirements should be calculated for additional milk yield (*Tüzemen*, 1990). Daily milk yield was found to be 7.8 kg for crossbreed cows and so lactation energy requirement was calculated for a crossbreed cow in the midst of its lactation period and producing daily 8 kg milk containing 4% fat and 3.5% protein. Lactation period was taken to be 245 day for crossbreed cows and energy requirements of the lactating and dry cows were calculated according to the values reported by *Çakır et al.* (1995).

In determination of the energy requirements of the grazing cattle, an increase in maintenance requirement of non-grazed cattle is proposed with the ratios 25, 50, 75 and 100% for cattle grazing in very good, good, medium and poor quality pastures respectively (*Tüzemen*, 1990; *Çakır et al.*, 1995). Accordingly, averages for grassland quality groups were calculated and additional energy requirements by pasture quality groups were added to normal maintenance requirements (*Table 2*, *Table 3*, and *Table 4*).

Table 2

Study villages by grassland quality degrees

Lower and Upper Bounds of Rangeland Quality Groups	Average Rangeland Quality	Rangeland Quality Groups	Number of Villages
30.8-36.7	33.75	1	3
39.2-45.5	42.35	2	3
48.4-52.1	50.25	3	3
Difference (3-1)	16.50	Total	9

Source: *Anonymous*, 2006

Table 3

Additional energy requirements for the grazing animals per unit of grassland quality

Rangeland Quality Degree (%)	Grazing Period (Day)	TDN Maintenance Requirement (kg/day)[1]	Total TDN Maintenance Requirement for Grazing Period (kg/day)	Additional Energy Requirement for Grazing Animals in Grazing Period (%)	Additional Energy Requirement in Grazing Period (kg)	Difference	Additional TDN Requirement per Unit Rangeland Quality (kg)
	(a)	(b)	(c=ab)	(d)	(e=c + (cd)/100)	(f=e-c)	(g=f/d)
1-25	180	3	540	100	1080	540.0	5.4
26-50	180	3	540	75	945	405.0	5.4
51-75	180	3	540	50	810	270.0	5.4
76-100	180	3	540	25	675	135.0	5.4
Average	180	3	540	62.5	877.5	337.5	5.4

Source: Own calculations and *Çakır et al.*, 1995

Table 4

Additional energy requirements for the grazing animals in study area

Rangeland Quality Sub-Groups	Lower Bound	Upper Bound	Group Average	The Highest Possible Rangeland Quality	Range land Quality Difference	Additional TDN Requirement per Unit Rangeland Quality (kg)[1]	Additional TDN Requirement for Rangeland Sub-Groups
(a)	(b)	(c)	[d=(b+c)/2]	(e)	(f=e-d)	(g)	(h=fg)
1	30.8	36.7	33.7	100	66.3	5.4	357.8
2	39.2	45.5	42.3	100	57.7	5.4	311.3
3	48.4	52.1	50.2	100	49.8	5.4	268.7
Average							312.6

Feeding of the calves were considered in three periods such as 1) from birth to weaning 2) from weaning to 1 year of age 3) from 1 year of age to the time 2-3

weeks before the first birth giving. Live weight gains were estimated for the young female crossbreed animals according to the table values reported by *Çakır et al.* (1995) for small breed dairy cattle.

Daily nutrient requirements were calculated according to the estimated daily live weight gains considering that dairy cattle continue growing till the five year of age (*Tüzemen*, 1990; *Çakır et al.*, 1995) and it has a live weight of 375 kg at this age (*Anonymous*, 1998). Total nutrient requirement considered in the plans was calculated by summing up all nutrient requirements for winter period, half of lactation and growth requirements in addition to extra energy requirements calculated according to rangeland quality for grazing period.

In the study area, lambs at weaning age (8 weeks) have reached the grazing period. Pregnancy falls in with winter period since mating happens in September and October (*Anonymous*, 2009). It was reported that supplement is not necessary during grazing period since lactation period falls in with grazing season and rangelands could cover all nutrient requirements of a lactating ewe (*Çakır et al.*, 1995).

Average live weight of an ewe was accepted to be 60 kg (*Anonymous*, 2009) and nutrient requirements were calculated separately for the first 100 days and last 50 days of pregnancy and for the first two months of lactation period including maintenance requirements according to the table values given by (*Çakır et al.*, 1995).

In covering the nutrient requirements firstly the feeds produced in the farms were considered and their TDN yields per hectare were calculated. Barley, grain vetch and wheat bran were restricted with 60, 20 and 15% of the total diet respectively (*Çakır et al.* 1995); *Coşkun et al.*, 1996; *Kaya and Yalçın*, 1999). In calculation of the nutrient requirements for 1 PU dairy cattle and sheep activities, principally it was accepted that maintenance requirements would be covered with roughages and concentrates respectively. Cereal straw, meadow hay and legume hay were restricted with 33% in total roughage diet. In sheep production concentrate supplement was considered only for the last 50 days of pregnancy and it was accepted that barley alone could suffice the supplement need (*Çakır et al.*, 1995).

The method reported by *Erkuş and Demirci* (1996) was adapted to the study area and stable and sheep fold requirements for one PU crossbreed dairy cattle and sheep activities were calculated according to (*Alkan*, 1972) and *Ekmekyapar* (2001) to be 11.8 m^2 and 1.38 m^2 respectively. In determination of viable farm organizations mean averages of all studied farms were used for the three rangeland sub-groups given in Table 1 and it was assumed that only dairy cattle energy requirements would differ with rangeland quality sub-groups. Actual irrigated, rainfed and fallow land shares in the total were maintained and meadow land was included in the plans with actual size.

RESULTS AND DISCUSSIONS

According to the results, only sheep activity was entered into the obtained plans as animal production and no difference appeared among the rangeland quality groups. For that reason, sheep activity was excluded from the plans and analysis was repeated. Results for organizations to provide viable farm income by rangeland subgroups were given in *Table 5*.

Table 5

Minimum viable farm organizations by grassland quality groups

Production Activity	Unit	Amount			
		Rangeland Quality Groups			General Mean Averages
		Group 1	Group 2	Group 3	
Plant Production					
Wheat (irrigated)	Ha	0.35	0.33	0.30	0.33
Wheat (rainfed)	Ha	1.17	1.16	1.14	1.16
Barley (irrigated)	Ha	0.21	0.19	0.18	0.20
Barley (rainfed)	Ha	0.69	0.69	0.68	0.69
Potato	Ha	0.28	0.26	0.24	0.26
Alfalfa	Ha	0.00	0.00	0.00	0.00
Sainfoin	Ha	0.34	0.35	0.36	0.35
Grain vetch (rainfed)	Ha	0.57	0.56	0.54	0.56
Meadow	**Ha**	**1.87**	**1.87**	**1.87**	**1.87**
Animal Production					
Dairy Cattle	PU	1.9	1.9	2.0	1.9
Feed Selling and Purchase					
Straw purchase	Kg	0.0	0.0	0.0	0.0
Meadow hay purchase	Kg	0.0	0.0	0.0	0.0
Legume hay purchase	Kg	0.0	0.0	0.0	0.0
Barley purchase	Kg	0.0	0.0	0.0	0.0
Grain vetch purchase	Kg	0.0	0.0	0.0	0.0
Wheat bran purchase	Kg	457.5	444.9	433.8	444.5
Fabricated concentrate pur.	Kg	126.1	120.9	117.8	123.3
Straw selling	Kg	0.0	0.0	0.0	0.0
Meadow hay selling	Kg	0.0	0.0	0.0	0.0
Legume hay selling	Kg	0.0	0.0	0.0	0.0
Barley selling	Kg	0.0	0.0	0.0	0.0
Grain vetch selling	Kg	0.0	0.0	0.0	0.0

In all plans obtained, the ratios for irrigated, rainfed and fallow land were maintained and meadow land existed in real sizes. Alfalfa did not enter to the plans and all other roughage and concentrate requirements for dairy cattle production except wheat bran and manufactured concentrate would be covered with farm production. So, other feed selling and purchasing activities did not find place in farm organization. Including meadow land, minimum viable farm size was calculated to be 6.42 ha in average for the all studied farms as 0.2 ha of difference was appeared between relatively poor and good rangeland quality groups as seen in *Table 6*.

Table 6

Resource use in minimum viable farm organizations by grassland quality groups

Limited Production Factors	Unit	Amount			
		Rangeland Quality Groups			General Mean Averages
		Group 1	Group 2	Group 3	
Total Labour Force	Hour	2248.4	2245.3	2243.0	2245.7
2nd Period Labour Force	Hour	859.6	853.1	847.8	853.6
3rd Period Labour Force	Hour	608.4	598.9	590.0	599.2
Total Capital	TL	4749.3	4761.3	4773.6	4761.4
Stable	m^2	22.3	22.8	23.2	22.7
Sheep Fold	m^2	0.0	0.0	0.0	0.0
Total Cultivated Land	Ha	4.65	4.55	4.45	4.55
Cultivated Land (irrigated)	Ha	0.84	0.78	0.72	0.78
Cultivated Land (rainfed)	Ha	2.78	2.75	2.72	2.75
Fallow	Ha	1.03	1.02	1.01	1.02
Meadow	Ha	1.87	1.87	1.87	1.87
Total Farm Land	Ha	6.52	6.42	6.32	6.42

From the relatively poor rangeland group (Group 1) towards the good one (Group 3) a decrease is obvious in wheat, barley, potato and grain vetch acreages except sainfoin. Despite of an increase in dairy cattle activity even though not significant a decrease in purchased amounts of bran and fabricated concentrates was obvious with an increase in rangeland quality from Group 1 to 3.

The villages in the study area were given in 3 groups. Between the first and third groups is there 16.5% of difference in average rangeland quality. Also, a 0.2 ha of farm size and 0.1 unit dairy cattle difference were calculated between these groups. This means that minimum viable farm size in the villages of the first group is 0.2 ha larger but has 0.1 unit less dairy cattle than those in the villages of the third group which have more quality (16.5%) rangelands. More clearly, a shift of 16.5% in rangeland quality brings about 0.2 ha of minimum viable farm size and 0.1 unit dairy cattle difference which is important regarding the magnitude of rangeland quality effect.

In Turkey, a number of studies i.e. *Çakal* (1976), *Demirci* (1978), *Kiziloglu* (1989), *Altun* (1990, 1992, 1993), *Peker* (1997), *Aksoyak* (2004), etc. were conducted to determine the minimum viable farm size in different regions of Turkey. However, neither of them considered the rangelands and their quality in their studies. Similarly, literature review did not prove any study conducted on this subject in the World as well. Only a few mentioned about minimum viable farm size (*Andriesse and Scholten*, 1983; *Cavero and Delgado*, 1984).

CONCLUSIONS

This study revealed that less number of grazing animals per farm but bigger farm land is required to ensure the viable farm income parallel to the decreases in pasture quality. This is an important result to be considered both in land consolidation works performed under the land and agrarian reform activities and in the grazing land improvement studies. The latter is the most important since land consolidation works take much time and it seems difficult to limit the number of grazing animals per farm.

Since low intensity animal production dependent on natural rangelands has been experienced in the region and rangeland quality is so effective on viable farm size, rangelands cannot be disregarded and left on its own fate. On the contrary, rangeland improvement and management projects should be put into action and their sustainability should be provided through rotational grazing plans and training of the members of rangeland management unions. These measures should also be supported with legislative regulations. Moreover, it is of vital importance to reduce stocking rate, prevent early grazing, control nomad movements. On the other hand, in order to assess the results of rangeland improvement studies, it is necessary to study the limits of change in rangeland quality due to improvement studies along with monitoring and impact assessment studies. In present study, the necessity of support and encouragement for animal production activities to better utilize the natural rangelands of eastern Anatolia towards increasing the farm income in the region was shown with concrete data and the findings can be applied to the study area and extended to the areas with similar characteristics.

However, this case study is a first instance in this regard and was conducted in the villages with a narrow range of rangeland quality (30.8-52.1%). In order to prove the study findings, there is a need for more robust and long term studies to be conducted in the villages with a wider range of rangeland quality.

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