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Twofold excessive utilization rate yields high financial equivalent but seriously threatens public rangelands in Turkey

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Abstract

The aim of this study was to estimate the utilization rate and financial equivalent of the utilized rangeland forage to quantify the extent of grazing pressure on the semiarid Turkish rangelands, and to attract the public attention to the importance of rangelands in national economy. The study was conducted in Erzurum province of Turkey. In permanent 12 representative sites in each of village rangelands, cages of 1 m height and 1 m × 1 m floor area, were placed and forage under cages was clipped to the ground at the end of the grazing seasons in 2007 and 2008. Simultaneously, the forage outside the cages was sampled with random quadrats. Financial equivalent of the utilized rangeland forage was estimated using surrogate market valuation method. In data analysis were employed descriptive statistical methods and one-way ANOVA test. According to the results, the average rangeland dry forage yield was 1012 kg.ha^{-1} and rangeland utilization rate was 69 per cent, roughly two-fold higher than suggested rates. Under the prevailing conditions, the financial equivalent of the utilized rangeland forage is about 526 TRY or 92 USD per hectare. It was concluded that utilization rate or grazing period should be deflated by 50% for sustainable resource use by allowing rangeland plants to regenerate.

Keywords: Rangeland forage, Semiarid rangelands, Financial equivalent, Surrogate market valuation, Eastern Anatolia

Introduction

Rangelands constitute the most important diversity and repository of the genetic resources. They contribute greatly to the ecosystem and enhance values of the farm products and promote rural tourism (Hopkins and Holz, 2006). They preserve soil and water (Altın et al., 2005) and release fresh water and oxygen. Rangelands are shelter and home of a variety of animals and plants, most of which are used for hunting or gathering by rural populations either for direct consumption or to be sold in markets. Rangelands also support honeybee farming as an important source of pollen and nectar. They provide free forage for domestic animals. Rangelands, owing to the above-mentioned benefits, have an important place in the livelihood of the rural populations and they greatly contribute to the national economy.

However, decades-long untimely and heavy grazing caused degradation and losses in functionality of the rangelands worldwide. It is thankfully that an awareness has been developed in Turkey and after the enactment of Pasture Law (Law No: 4342) in 1998, the National Rangeland Improvement and Management Scheme was put into action in the same year by the former Ministry of Agriculture and Rural Affairs in order to increase and maintain the productivity of degraded rangelands. Since then, governments have started to transfer substantial amount of funds to restore and rehabilitate the degraded rangelands. Nevertheless, for the sustainability of fund allocation, it is of great importance to keep rangelands in the agenda. Yet, scarcity of capital makes investment decisions one of the most important challenges that managers, donors or policy makers face across various options. More importantly, financial considerations have the crucial role in prioritization or assessing the capital investment opportunities, even some non-financial factors may also have to be regarded. So, in order to keep the rangelands in top of the

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investment opportunities list, it is of importance to quantify the contribution of rangelands to the economy to convince the policy makers and the donors on the profitability of investing in rangelands. Yet, this is a difficult task and most of the above-mentioned benefits obtained from the rangelands cannot be monetized and their actual economic and social values either are underestimated or not considered adequately (Cousins, 1999). Nevertheless, estimation of the dry forage yields and its utilized percentage may help quantify the financial equivalent of the rangeland forage and so their annual contribution to the economy, which ultimately show the importance of rangelands even when only forage production is considered, and other utilities are disregarded.

Among all the seven geographical regions, Eastern Anatolia seems to have very favorable conditions for animal production owing to its vast meadow and rangeland asset. Rangeland dependent extensive animal production has been a way of livelihood generation in the region for centuries. In Turkey, rangelands are commonly used vegetation covers, whose rights are left to the legal entity of each village with certain demarcation by the laws. Village flocks and herds graze separately under the supervision of herders or shepherds with daily excursions starting with sunrise and ending with the sunset (Kara et al., 2014).

A grazed, trampled or destroyed part of rangeland forage has been reported to be a measure of utilization for given rangeland, and its share in total production is described as rangeland utilization rate. In proper rangeland utilization, about 50% of utilization rate is recommended as normal suggesting that the rest should be left to allow rangeland to regenerate (Gökkuş and Koç, 2001). However, such a generalization may not be valid for all rangeland types and that utilization rate may vary according to the type of vegetation cover. For example, utilization rates of 20–30% for alpine tundra, 35–45% for western mountainous rangelands, 40–50% for short grass prairies, 45–60% for tallgrass prairies, and 45–55% for cool season grasslands have been recommended (Vallentine, 1990, cited in Gökkuş and Koç, 2001). Similarly, it has been reported that much less of rangeland forage should be grazed when rangeland condition is poor. Accordingly, 25–30% and 30–40% of utilization rates were suggested for poor and moderate condition rangelands and 50–55% of utilization rate was recommended for very good condition rangelands (Gökkuş and Koç, 2001).

In the rangeland related studies hitherto conducted in Turkey, mainly botanical composition was examined and the studies on forage yield, animal grazing and utilization are scarce and not addressed adequately. More importantly, previously conducted studies to determine the dry forage yield of the rangelands were limited with small-scale trial plots in protected, non-grazed areas, and determination of the utilization rate was out of their scope. Since there is little or no information on the degree of grazing and utilization rate of Turkish rangelands, generally approximate values have been used in rangeland rehabilitation studies in Turkey. Differing from the previous ones, the present study was conducted in a considerably wider area covering continuously grazed rangelands in 11 villages of 5 districts. It is expected that study findings will provide valuable information to be needed in future rangeland and animal related studies, and also be beneficial in sustainable fund allocation for the rangeland restoration and rehabilitation investments, not only in Turkey but also in countries sharing similar agroecological conditions, cultural and historical backgrounds of rangeland use pattern.

Materials and Methods

Material

The primary material of this study was obtained from the forage harvested from cages and random quadrats at the permanent 12 sites in the rangelands of 11 villages in Erzurum province, Turkey. In addition, the records of the official institutions in obtaining the relevant information related to the study subject were used as secondary material.

Study Area

The study area covers Erzurum province that reflects the main characteristics of the Eastern Anatolia region of Turkey regarding geography, climate, production type, and pattern (Figure 1). This region is known for its suitability for livestock production due to its one-third share in total rangeland asset of Turkey.

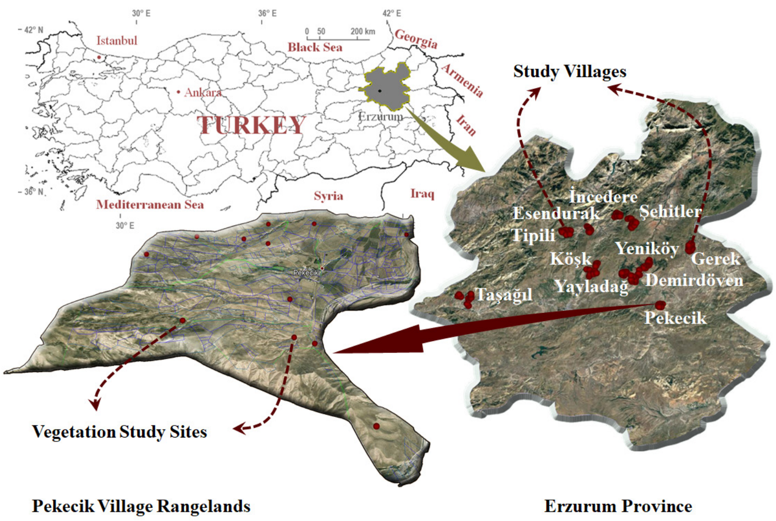

Figure 1. The study area in Turkey

High amount of rangeland asset and unfavorable climatic conditions, which limit crop production, have determined the way of livelihood generation, and so rangeland dependent livestock production system has prevailed for centuries in the region.

Erzurum has very rugged geography and very harsh terrestrial climate and is located within the 39 54' 31'' northern latitudes and 41 16' 37'' eastern longitudes. Altitude is ranging from 2000 m asl in plateaus to 3000 m asl and higher in the mountains and can be as low as 1000-1100 m asl in valley floors and 1500 – 1800 m asl in plains. Despite the existence of plain areas, the topography is fragmented in general and the dominant vegetation is steppe grasses (60%) as woodland is scarce (%6). Winters are long and harsh, and summers are short and hot. In a long term (1975 to 2006), the average number of frozen days and the days with snow cover are 154 and 113 days, respectively, while annual average temperature and total precipitation are 5.5 °C and 453.3 mm in respective order (TÜMAS, 2013). The annual and grazing season precipitations during 2007 and 2008 are presented in Table 1. According to the meteorological data, the year 2008 was distinctively draught compared to the previous year.

Table 1. Annual and seasonal precipitation during the years 2007 and 2008 (mm)

Period	Study Years		Difference	%
	2007	2008		
April-October	308.5	234.1	–74.4	24.1
Year Round	436.6	317.8	–118.8	27.2

Source: TÜMAS (2013)

Selection of the villages

In selection of the study villages, special emphasis was given on their representative ability over the surrounding area. Villages from different districts were purposively selected among those free from nomadic movements and boundary problems, and for which rangeland demarcation and allocation studies have been completed. Thus, from Aşkale, Narman, Pasinler, Köprüköy, Horasan, and Tortum districts in a total of 11 villages were selected for the study. In the study area, the altitude of grazing sites varied between 1593 m and 2847 m asl.

Study villages are apart from each other from a minimum of 7.9 km to a maximum of 126.5 km. Although sharing similar production patterns, they differ from each other regarding the acreage of rangelands and the fluctuating total animal asset (Table 2). Because the livestock is not of the same size or weight and weight variations require adjustments, the animal asset of the villages was expressed in animal unit equivalent (1 AU = 500 kg live weight). In animal unit conversions, the rates suggested in Turkey's Pasture Regulation (MBS, 1998) were used.

Calculation of the rangeland utilization rate

Rangeland utilization rate describes the percentage of forage that is grazed or removed by animals from the total forage amount produced by rangeland which should satisfy the condition not to cause rangeland degradation (Gökkuş and Koç, 2001). In order to determine the dry forage yield of the rangelands, cages with 1 m height and 1 m × 1 m floor area were placed in each of the 12 representative permanent sites in the rangelands of every village before the grazing seasons of 2007 and 2008, and the forage under the cages was clipped to the ground at the end of the grazing season, corresponding to the seasonal yield.

At the end of the grazing season of the year 2007, it was observed that 31 and 12 out of 132 cages were lost and disassembled, respectively. In the following year before the grazing season, the lost and disassembled cages were fixed and completed to 132. Again, at the end of the grazing season of the second year, 28 cages were lost or unsuitable for data collection. Because of the lost or disassembled cages, unavailable observations were treated as missing data and the observations from 89 cages in the first year and 104 cages in the second year were used in forage yield and utilization rate calculations.

In order to determine the dry forage amount removed from the rangelands during the grazing period, we considered the dry stubble yield at the end of the grazing season (Gökkuş and Koç, 2001). Thus, the rangeland stubble was sampled through four random quadrats in surrounding areas of each cage at the end of the grazing season. The rangeland stubble in the four random quadrats, equivalent to cage floor area (4 quadrats = 1.0 m^2), was clipped to the ground. The harvest weights of the forage and the stubble, and their dry weights after dehydration at 70 °C for 48 h in an oven were recorded.

Thus, average dry forage yields and four quadrat yields were obtained for each of the permanent sites in the village rangelands. Subsequently, the utilized or removed amount of rangeland forage was calculated by subtracting quadrat stubble yield from the cage forage yield and converted to per hectare yield. Finally, the utilization rate was calculated by dividing the utilized dry forage by the dry forage yield (Gökkuş and Koç, 2001).

Table 2. Rangeland and animal asset (in animal units) of the study villages

Villages in the Study Area	Rangeland Asset[1] (ha) (a)	Animal Asset (AU)[2]	
		2007 (b)	2008 (c)
Köşk	7349	1160	1418
Taşağıl	1177	518	600
Yeniköy	576	674	606
Yayladağ	452	538	510
Demirdöven	430	1159	832
Pekecik	217	111	239
Gerek	2138	734	941
Şehitler	883	716	718
Esendurak	191	79	140
Tipili	1548	330	442
İncedere	595	245	327
Total	15556	6264	6772

[1]Official records obtained from the directorates of agriculture operating in the study area

[2]Calculated on the basis of the official records

Calculation of the financial equivalent of utilized rangeland forage

We used surrogate market (also called substitute good) valuation method to estimate the value of the rangeland forage. The concept of the surrogate market or substitute good is used when one cannot directly estimate the market prices for certain environmental or non-market goods. In this case, valuation is made through the price of another similar good or service (proxy) to be substituted for the non-market good or service of interest (NRC, 1999; Cousins, 1999; Rehber, 1999; Torrell et al., 2014). Thus, dried meadow hay was considered to be the substitute of rangeland forage and the dried meadow hay prices available at Erzurum Commodity Exchange were used as a financial proxy to value the rangeland forage.

Data analysis

One of the important preconditions for the parametric statistical methods is the assumption of normal distribution for the variables under consideration, and it was tested using Skewness and Curtosis test. Yet, this test revealed that normality assumption was not satisfied, even after data transformation attempts. However, theoretical justification for the normality assumption is the central limit theorem which states that when sample size has 100 or more observations, violation of the normality is not a major issue (Gujarati, 1995). Following this theorem, we employed descriptive statistical methods and one-way variance analysis test (ANOVA), along with the non-parametric Kruskal-Wallis test as a robust alternative to one-way ANOVA (Sokal and Rohlf, 1995; Zar, 1999). Statistical analysis was performed using SPSS version 23.0 for Windows (IBM Corp. 2015).

Results

Rangeland dry forage yield

In the first year of the study, the highest dry forage yield was obtained from the Pekecik village rangelands of Köprüköy district (195.8 g.m^{-2}) and the lowest yield (60.9 g.m^{-2}) was from Yayladağ village rangelands of Pasinler district. In the second year of the study, on the other hand, the highest dry forage yield was obtained from the Tipili village rangelands of Tortum district (117 g.m^{-2}), while the lowest dry forage yields were from Yeniköy village rangelands of Pasinler district (43.7 g.m^{-2}). Again, the average dry forage yield of the whole study area was realized to be 126.6 g.m^{-2} and 80.5 g.m^{-2} for the first and second years, respectively. According to the results, the villages did not differ significantly (p>0.05) regarding the dry forage yield but the difference between the study years was very significant (p<0.01). The average dry forage yield of the cages for all villages and both years was 101.2 g.m^{-2} and the same per hectare was 1012 kg (Table 3).

Rangeland utilization rate

The rangeland utilization factor or rate was calculated as 66.1 and 71.6 per cent for the years 2007 and 2008, respectively, making an average of 69.1 per cent over two years (Table 3). The difference between the years was significant (p<0.05). Again, there were significant utilization rate differences among the villages (p<0.01). The lowest utilization rate was calculated for Köşk village (53.2% while the highest utilization rates were recorded for Yayladağ and Yeniköy villages (80.2%).

Estimation of the optimum length of the grazing period

For sustainable use, the rangeland utilization rate should satisfy not to cause rangeland degradation (Duan et al., 2017). For that reason, it should be arranged according to the rangeland condition in order to allow rangeland plants to regenerate. As stated earlier, 25–30% and 30–40% of utilization rates were suggested for poor and moderate condition rangelands (Gökkuş and Koç, 2001), although Teague et al. (2009) advised even much less utilization levels (20–25%) to ensure maintenance of rangeland in an excellent condition. Based on the collected data and the suggested utilization rates, we could estimate the optimum length of the grazing period for the study area to ensure regeneration of the rangeland plants at the existing stocking rates. So, following Gökkuş and Koç (2001), we considered two utilization rate scenarios in calculating the optimum length of grazing period in Table 4. According to Table 4, optimum length of grazing period varies between 60 and 80 days making a difference of 20 days between the two scenarios considered. The maximum length of the grazing period was calculated to be 80 days according to the second and the most optimistic scenario, in which 40% of utilization rate was taken into account.

The financial contribution of the rangelands to the national economy as a forage source

In the calculation of the financial contribution to the national economy, rangelands were taken into account only as a source of forage and all other possible utilities were ignored. The financial contribution of one hectare of rangeland area to

Table 3. The rangeland dry forage yield, stubble yield, utilized dry forage and utilization rate by the study years

Study Years	N	Dry Forage Yield (kg.ha^{-1}) (a)		Dry Stubble Yield (kg.ha^{-1}) (b)		Utilized Dry Forage (kg.ha^{-1}) (c = a – b)		Utilization Rate (%) (d = c × a^{-1})	
		$\bar{x}$	$S_{\bar{x}}$	$\bar{x}$	$S_{\bar{x}}$	$\bar{x}$	$S_{\bar{x}}$	$\bar{x}$	$S_{\bar{x}}$
2007	89	1255.7	99.6	396.4	32.7	859.3	88.0	66.1	2.2
2008	104	804.0	63.7	237.5	28.4	566.5	47.7	71.6	1.8
Total	193	1012.33	59.5	310.8	22.2	701.6	49.0	69.1	1.4

Table 4. The optimum length of grazing period at the existing number of grazing animals in the study area based on the suggested utilization rates

Items	Explanations	Scenarios for the optimum length of grazing periods	
		The First scenario	The Second Scenario
Suggested utilization rate (%)[3w]	(a)	30	40
Rangeland dry forage yield per hectare (kg×ha^{-1})[4]	(b)	1012	1012
Rangeland dry forage quantity to be grazed per hectare (kg×ha^{-1})	(c=a×b×100^{-1})	303.6	404.8
Herbage allowance for one AU (500 kg live weight) per day (kg×day^{-1})[3]	(d)	12.5	12.5
The number of animals to be allowed to graze per hectare per day (AU×day^{-1})	(e=c×d^{-1})	24.3	32.4
Total rangeland acreage in the study area (ha)[5]	(f)	15556	15556
Total number of animals to be allowed to graze in one day (AU×day^{-1})	(g=e×f)	378011	504014
The number of total grazing animals in the study area (AU)[5]	(h)	6264	6264
The total length of the grazing period to be considered in the study area (day)	(j=g×h^{-1})	60.3	80.5

[3]Gökkuş and Koç, (2001) [4]Present study results (Table 3) [5]Table 2

Table 5. The contribution of the poor to moderate condition rangelands to the economy in Erzurum

Items	Value
Rangeland dry forage yield (kg×ha^{-1})[6]	1012
Utilized dry forage (kg×ha^{-1})[6]	701
Dry meadow hay price for the year 2019 (TRY×kg^{-1})[7]	0.75
Financial equivalent of the rangeland forage (TRY×ha^{-1})	525.8
Financial equivalent of the rangeland forage (1 USD = 5.715 TRY) (USD×ha^{-1})	92.0

[6]Table 3; [7]ETB (2019)

the economy was calculated using the dry meadow hay prices for the year 2019, obtained from the Erzurum Commodity Exchange, and were used as a financial proxy to determine the value of the rangeland forage (Table 5).

According to the calculations presented in Table 5, it can be said that study area rangelands make an annual financial contribution of 525.8 TRY or 92.0 USD (1 TRY = 0.175 USD) per hectare at the present utilization rates.

Discussion

The main focus of this study was the rangeland utilization and their financial contribution to the economy. This was challenged by estimating the dry forage yield and its utilized portion. Of course, type, depth and nutrient content of soils, sloping degree, prevailing wind directions, evapotranspiration are all important factors affecting rangeland biomass. However, for the ease and simplicity of the study these factors were not handled, and they were kept beyond the scope of this study and have been left as the subjects for further studies. Moreover, the findings related to rangeland vegetation and condition were not touched in this study because a number of previously conducted studies in the region revealed more or less similar patterns (Erkovan et al., 2003; Dumlu et al., 2011; Avağ et al., 2012; Çakal, 2016).

Regarding the financial contribution of rangelands to economy, of course, we admit that it certainly would be illogical to limit it only to source of herbage. However, what we would like to do in this paper is to emphasize the importance of rangelands even when only forage production is considered, and other utilities of rangelands are disregarded.

The average rangeland dry forage yield reported in this study is important in terms of giving an idea on dry forage yield of the rangelands sharing similar ecological conditions. We have estimated not only the dry forage yield but also determined how much of it is consumed or utilized by grazing animals.

Regarding the rangeland dry forage yields, the villages did not differ significantly ($p>0.05$) from each other but a significant yield difference was detected between the study years ($p<0.01$). The reason for this is most likely precipitation. In the areas with less than 600 mm annual precipitation, moisture played a key role in the composition, structure, and density of the plant communities (Kutiel and Lavee, 1999, cited in Maren et al., 2015) and so rangeland forage production is fluctuated and mainly determined by rainfall (Duan et al., 2017). Thus, about 36% of the yield gap in the second year was likely due to the low precipitation in the year; 27% and 24% less precipitation was realized for all year round and for the vegetation period from April to October, respectively (Table 1). In line with our findings, a significant effect of the precipitation has also been reported by O'Connor and Rouxt (1995), Khumalo and Holechek (2005), Browning et al. (2012).

Although significantly differed among the villages, most likely due to the stocking rate differences, the rangeland utilization factor or rate was 66.1 and 71.6 per cent for the years 2007 and 2008, respectively. Low dry forage yields in the second year of the study brought about relatively higher utilization rates. Thus, heavy grazing problem significantly worsens ($p<0.05$) in the years of low forage production (Table 3). An average of 69.1 per cent utilization rate over two years is twofold higher than the suggested value (Gökkuş and Koç, 2001; Teague et al., 2009), and indicates a heavy grazing pressure on rangelands in particular for the studied area, and in general for the eastern Anatolia.

At this excessively high utilization rates, we calculated the financial equivalent of utilized rangeland forage to be 92.0 USD (1 TRY = 0.175 USD) per hectare in the present study. Rangeland condition of the studied rangeland sites was previously presented elsewhere that it varied from poor to moderate condition (Kara et al., 2015; Kara, 2019). Again, Avağ et al., (2012) reported that the majority of rangeland asset in Erzurum and eastern Anatolia, were in a moderate condition i.e. 63 and 60 percent. That is, about 2,519 thousand ha (60%) out of total 4,198,046 ha of the rangeland assets of eastern Anatolia (GTHB, 2018) are in a moderate condition. Thus, even when considering only the moderate condition rangelands, we could infer that the annual contribution of rangelands of eastern Anatolia to Turkish economy is about 232 million (2519 thousand ha × 92.0 $\$.ha^{-1}$) US dollars. However, this high financial equivalent has been accomplished at the expense of rapid rangeland degradation, which means killing the goose that lays golden egg. In order to achieve sustainability either the length of the grazing period should be shortened, or existing stocking rates should be deflated by 50% to alleviate the heavy grazing pressure so that rangeland plants can regenerate.

Because village rangelands in Turkey are in common use, management of the grazing according to the herbage production, or deflating the existing stocking rates by 50 percent is an extremely difficult task since it requires halving the existing number of grazing animals. In a private farm with a private rangeland property, farmer can decide on the optimum stocking rate for better use of his or her rangeland. In common use, however, every farmer tries to use it as much as he or she can, in an opportunistic manner, ignoring the capacity of the rangeland. For that reason, instead of deflating stocking rates, shortening the grazing period may be easier.

As illustrated in Table 4, considering the suggested utilization rates by Gökkuş and Koç (2001), the maximum length of the grazing period was calculated 80 days (roughly three months) according to the most optimistic scenario (Table 4). As a matter of fact, roughly this length of grazing period could be achieved by shrinking the present utilization rate by 50% at the existing stocking rate without halving the number of grazing animals since the actual grazing period is for about six months in the study area (Kara et al., 2009).

Shortening the grazing period is also important for the profitability of the rangeland restoration investments since rehabilitated rangeland parts will soon be back to the previous condition in a few years without paying back the investment or harvesting the targeted results at the actual utilization level (Kara et al., 2014).

Conclusion

Although overgrazing is a well-known fact for Turkish rangelands, this study quantified the extent and severity of this problem. Again, this study also showed the huge amount of financial contribution of the rangelands even when considering their forage production for domestic animals. However, it is an inevitable truth that such a financial contribution is not sustainable at the existing utilization rates and achieved at the expense of rapid rangeland degradation. For this reason, it would not be meaningful to invest in rehabilitation of the rangelands unless effective and practical measures are taken.

For a sustainable economic contribution, urgent and immediate measures should necessarily be taken toward bringing down the high utilization rate to reasonable levels through setting fair stocking rate or grazing periods, i.e. utilization rate or grazing period should be halved to allow rangeland plants to gather strength and regenerate. Therefore, we suggest three months of grazing period starting from early June to late August.

Although present study findings represent the rangelands in Erzurum province of Turkey, we can make inferences and generalize the results for the rangelands sharing similar agro-ecological conditions, i.e. from poor to moderate condition rangelands in similar geographic and climatic conditions in eastern Anatolia, considering the wider study area, which covers 11 villages in five districts, making a total of 15556-hectare rangelands. We expect that the findings of this study will contribute positively to future studies in this regard, and that results could be used in the management of the rangelands, particularly in the improvement and rehabilitation practices not only in Turkey but also in countries sharing similar agro-ecological conditions, cultural and historical backgrounds of rangeland use patterns.

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