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Hazard assessment of livestock pressure in Khuzestan province, Iran

M. Elhaeesahar, M. Masoudi*

Department of Natural Resources and Environmental Engineering, College of Agriculture, Shiraz University, Shiraz, I. R. Iran

* Corresponding Author: masoudi@shirazu.ac.ir
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ABSTRACT- Overgrazing accelerates soil and vegetation degradation in rangelands. This study aimed to assess livestock pressure on natural resources of Khuzestan province, located in the south western part of Iran, using Geographic Information System (GIS) tools and a model-based procedure. FAO/UNEP Model which uses a ratio of potential carrying capacity of region to current livestock population density as an Index for livestock pressure was selected for this purpose. However, the model was modified in this study to achieve a better estimation of pressure index according to the actual conditions of the region. Parameters used to modify this methodology were: Topographic and Local parameters. Local parameters were annual consumption for livestock unit in the study area, dependency of each livestock to pasture, number of livestock unit for each animal and land use map. Hazard map of pressure of livestock was prepared after overlying and calculating different parameters in a GIS. According to the results, hazard classes of severe and very severe included about 70% of natural resources in the study area. Areas including higher classes of hazard severity were identified in the west, center and south east part of the region, mostly. This is because of low potential of natural rangeland to grow enough forage and also a high number of livestock.

INTRODUCTION

Desertification and biodiversity loss have been serious environmental problems influencing people's lives, economic development and political stability (Warren et al., 1996). Vegetation destruction resulting from overgrazing and other unsuitable uses of rangeland is one of the most common causes of desertification and biodiversity loss. There are numerous desertified lands over the world, especially in arid and semiarid zones (Dregne, 2002), resulting from human over-exploitation such as mining, clear-cutting, and overgrazing. Livestock grazing is a dominant land-use activity in semi-natural and managed rangelands (Soderstrom et al., 2001). Heavy grazing can disturb rangeland (Yates et al., 2000). A study of grazing effects on species diversity and richness of rangeland vegetation has reported that grazing impacts on species composition, vegetation cover, canopy height, biomass and soil environment were sensitive to grazing rate in the rangeland (Pour and Ejtehadi, 1997).

Rangeland ecosystems have been grazed by small ruminants mainly sheep and goats, for more than 5000 years (Noy-Meir and Seligman, 1979, Perevolotsky and Seligman, 1998). Arid and semi-arid grasslands in the Middle East have also been evolved for more than 8000–9000 years (Smith, 1995). Livestock play an important role in human-being livelihood. Nowadays, livestock have been grown generally to satisfy the same ancient demands- e.g., milk, meat, wool and manure. As shown in Fig.1, livestock in the area grew in big herds. Today, it is also as a saving-account for villagers and nomads' family so as they sell livestock at local markets whenever they are in an urgent need of money.

Heavy grazing can cause soil erosion, loss of soil structure, and deterioration of soil environment (Faraggitaki, 1985). Apart from the key role of livestock in local and national economy, they have always been blamed for their effects on accelerating land degradation. Environmental degradation, caused by human pressure and land use changes, has become a major problem worldwide (Erlich, 1988; Wilson, 1992). Grazing with heavy stocking has also multiple effects on agro-ecosystems by defoliating plants and consequently influencing their growth, strength and regeneration processes. Besides, it reduces the diversity of plant species as well as vegetation crown cover and amount of biomass. By reducing vegetation crown cover, water infiltration rate decreases and wind/water soil erosion also increases (Mwendera and Mohamed Saleem, 1996; Le Houerou, 1996; Asadu et al., 1999; Taddese, 2001). Compacted soil caused by herd becomes strong, making it difficult for new shoots both to penetrate roots in and to emerge stems out of the soil. Such a soil is unlikely to drain well and it will pond after a moderate rainfall. Soil particles from these zones will be susceptible to erosion carrying particles, organic matter and phosphorus to surface waters.

When a region is affected by heavy stocking grazing, recovery will occur within a long period of time. The consequences are minor and reversible if grazing intensity is either low or moderate. Conversely, they become major and irreversible if it is very high. So, it is very important to have a general view about grazing intensity, degradation hazard and the consequences to plan natural rangeland accurately.

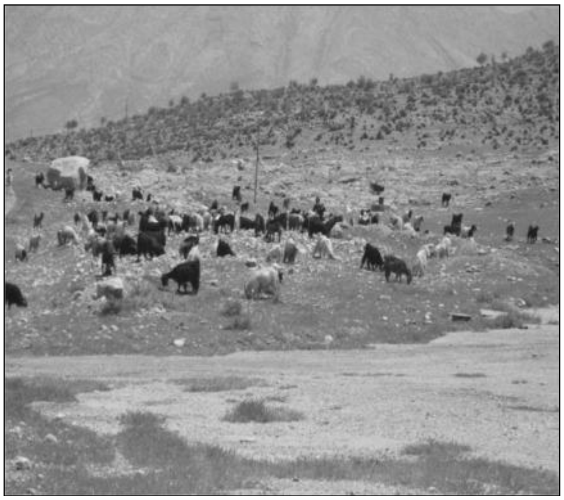

Fig 1. Goat is one kind of livestock in the study area, grew in big herds.

Ahmadian et al. (2014) investigated five major processes of land degradation with two aspects including “current status” and “inherent risk”. Also, the maps of livestock pressure and human population were prepared. The highest livestock pressure (58.3%) was recorded in the center of region. Overall, according to the obtained results, the natural and human factors, particularly livestock pressure, were effective to create these conditions.

Andriamandroso et al. (2016) attempted to explore the possibility of monitoring the individual jaw movements and the differentiation of bites in grazing animals. The review clearly demonstrated the abilities of mechanical, acoustic and electromyography sensors to classify the different types of jaw movements.

Habib et al. (2016) calculated feed requirements of livestock species from the standard tables published by US National Research Council. The results showed that indigenous feed resources were short for livestock and poultry requirements. The supply and demand gap for dry biomass, crude protein (CP) and metabolizable energy (ME) were 19.4%, 37.2% and 38.0%, respectively.

The main objective of the study was to evaluate the pressure of livestock in the region according to the classification of hazard severity, while the number and type of livestock have been considered as the key factors to determine the hazard classes. In this research, a model of assessing livestock pressure has been proposed, using two types of data including thematic maps and attributions which have been stored, processed and analyzed within ArcMap GIS environment. All the data were obtained from the local offices and were checked through intensive field work.

Study Area

Khuzestan was selected as a study area for a test assessment of drought vulnerability. It covers an area of 63633 km^2, which lies between the latitudes of 29°59′ and 33°01′ N and the longitudes of 46°48′ and 50°30′ E. The population of the state has increased from 2 million in 1978 before the revolution to 4 million in 2006, with an effective doubling of the population in less than thirty years. The elevation varies from sea level to around 3500m in the Sefid Kuh and Mangast. Climate differs widely but most parts of the province are arid and average of precipitation is 266 mm per year, but mean annual rainfall reaches 950 mm in the north eastern parts. The main period of precipitation is during the winter. Temperature in most parts reaches above 50°C during summer.

Fig 2. Location of Study Area in Iran

MATERIALS AND METHODS

FAO/UNEP Model of Livestock pressure assessment (FAO-UNEP, 1984) was recommended as the main framework to assess livestock pressure on the natural rangeland. The model was adopted for the current study, considering some modifications to produce a hazard map, presenting a better estimation of pressure index according to the actual conditions of the region. To assess the pressure index of livestock, the following steps were taken:

Estimating Potential Productivity of Rangeland

Potential productivity was used as an indicator to classify rangelands. It indicates how much a rangeland is able to produce forage (dry matter in kilogram per year in ha) in a given climate condition without considering the impact of anthropogenic activity. It has been calculated in the following steps:

Assessing Consumable Dry Matter (CDM)

The following equation was employed to assess consumable dry matter. It is based on the amount of annual rainfall (R) for zones with winter rainfall (Le Houerou and Le Hoste, 1977), adopted by FAO/UNEP (FAO/UNEP 1984).

$$CDM\ (kg / ha) = 2.17 \times R\ (mm) - 103.7$$

Applying the equation, the map of the annual rainfall for the region was turned into CMD map in ArcMap GIS software.

Assessing CMD'

The method uses soil conditions to achieve a better and more probable estimation of CMD than the above equation provides. It emphasizes the influence of soil conditions- its capability and suitability- to produce biomass and annual dry matter of forage consequently. Hereby, a new value of CDM was demonstrated by CMD' which is calculated from equations, presented in Table 1, offered by FAO/UNEP (1984) and Kharin (1986). The soil condition of the region was extracted from existing reports (Research Institute of Planning and Agricultural economics, 2000). Finally, CDM' map of the region was produced by overlaying map of land units, including attributes of soil suitability, on the CDM map and applying equations of Table 1 in ArcMap GIS.

Assessing Potential of Carrying Capacity (PCC)

To assess this, a ratio of CDM' to 440 is used:
Potential of Carrying Capacity (PCC) = CDM' ÷ 440.
The number 440 is the amount of the dried forage (kg) needed for each livestock unit (sheep) per year (1.2 kg per day; Report, Research (Research Institute of Planning and Agricultural economics, 2000). while the forage need of each livestock unit (cow) per annum is estimated as 2000 kg in FAO/UNEP (1984) method.

So, the PCC indicates the number of livestock unit (L.U.) which can be supported by a hectar of a certain rangeland annually. In this study, “sheep” was considered as the livestock unit; however, “cow” is the unit in FAO/UNEP method.

Assessing Actual Density of Livestock (ADL)

To assess ADL, first, equivalent livestock units are defined for various animals (Natural Resources Bureau of Fars Province, 2003). It was indicated in Table 2 for the animals in the study area. Then, animal dependencies on natural resources area were considered because farmers use some other complementary food resources such as agricultural debris to feed their animals. It was also demonstrated in Table 2 for different animal types of the region. So, Active Livestock Unit (ALU) which depends on natural resources area was calculated by multiplying the number of animals in each sub-region (Table 3) by the equivalent animal unit by the corresponding dependency rate. The total number of sub-regions which indicates sub divisions of townships in the province was 82. Then, the total number of ALU was divided into the area of natural resources in each sub-region to calculate the actual density of livestock in the natural resources area per ha.
Number of Active Livestock Units (ALU) = (no. sheep ×1.0 × 0.6) + (no. goat × 0.75 ×0.7) + (no. native cow × 4.0 × 0.26) + (no. hybrid cow × 6.5 × 0.20) + (no. foreign cow × 9.5 × 0.05) + (no. camel × 5.5 ×0.9) + (no. buffalo × 6.5 ×0.75) + (no. of other livestock like donkey × 4.5 × 0.75)

Table 1. CDM's modified Equations, based on soil suitability for Natural Resources in the land units

CDM's modified Equations	Soil Suitability for natural resources	Soil Limitations
CDM' = CDM + 0.25 CDM	Good S1,S2	No limitations
CDM'= CDM - 0.25 CDM	Medium S3	Medium limitations
CDM'= CDM - 0.50 CDM	Low S4 ,S5	Severe limitations
CDM'= CDM - 0.75 CDM	Poor, very poor N1 ,N2	Absolute Non-suitable soils

Table 2. Equivalent Animal Unit and Dependencies on Range (%)

	livestock units							
	Sheep	Goat	endemic	Cattle Hybrid	Exotic	Buffalo	Camel	Others (like donkey)
Equivalent Animal Unit	1	0.75	4	6.5	9.5	6.5	5.5	4.5
Dependencies on Range(%)	60	70	26	20	5	75	90	75

Table 3. Local Statistics for Livestock in the regions

Township	umber of livestock					
	Sheep	Goat	Cattle	Buffalo	Camel	Others (like donkey)
Abadan	2488	485	8872	1272	0	
Omidye	58844	32412	9838	180	401	907
Andica	145115	55809	5481	13	0	1597
Andimeshk	239062	107104	14809	2319	0	8789
Ahvaz	437513	14333	88237	34026	403	8029
Izeh	387902	340528	47642	1423	0	7911
Baghmalek	101796	119629	16617	30	0	6060
Bandar-mahshahr	77954	15177	10100	253	0	270
Behbahan	113321	98976	35089	575	482	4754
Khoramshahr	15284	11155	11405	379	0	212
Dezful	424033	119235	31845	22118	0	8370
Susangerd	207117	2804	34420	19290	624	1507
Ramshir	95499	5294	9425	0	198	810
Ramhormoz	129464	11792	25936	3700	212	3640
Shadgan	60969	2311	39131	13727	0	101
Shush	338692	25842	47272	15665	2277	4875
Shushtar	152209	26928	32589	15928	0	2761
Gotvand	90868	8953	11513	3320	0	3587
Lali	85860	35630	5274	16	0	2278
Masjed-solyman	265736	126838	26161	1033	0	9258
Haftkal	83535	22047	7292	45	0	1772
Hendijan	58073	18634	5806	0	850	1159
Hovyzeh	80775	1121	13631	5209	2307	762

ADL in the altitude of mountain range, the livestock pressure class from slope more than 40% in the mountainous area was considered class one or without any hazard. Also, for other parts of region adjusted ADL was calculated based on the area (ha) of natural resources minus the area from slope more than 40% in the mountains in each sub-region. The maps of ALU and adjusted ADL were produced for the region, including all sub-regions in ArcMap GIS.

Assessing Livestock Pressure (LP)

Comparing the map of potential carrying capacity (PCC) with the actual density of livestock (adjusted ADL) presents the difference between natural potential of rangeland to supply forage sustainably and actual demands. To produce a hazard map of degradation, the maps (the PCC and the ADL) were overlaid (divide) to present weights of Potential conditions against actual ones. Then, the final map was classified by adopted FAO/UNEP pre-defined categories to produce classified hazard map of the region. The categories, employed in this research, are demonstrated in Table 4.

Table 4. Severity classes defined for livestock Pressure assessment

None	Slight	Moderate	Severe	Very Severe
≥ 5	1.5 – 5	1.0 – 1.5	0.5 – 1.0	< 0.5

Pressure of livestock = Potential of Carrying Capacity (PCC) / Actual Density of Livestock (ADL)

RESULTS AND DISCUSSION

The natural vegetation cover reflects the climatic and soil conditions but is also affected by anthropogenic activities like encroachment for cultivation and grazing. As a result, encroachment of the marginally hilly areas that were formerly the best grazing lands has become a high risk land use. At the same time, overgrazing in the remaining rangelands gets accelerated by the ever increasing concentration of the livestock on rangelands. This replacement has been fast in the recent decade. Often all the woody plants, not leaving even the small sub shrubs, have been cut and disappeared around the villages. Also, grazing pressure seems to have become much intensive in the past couple of decades than it was before. It urgently requires proper ‘rangeland management’, based on grazing capacity. The implementation of management strategies is, of course, very difficult to introduce because of the socio-economic compulsions of the rural population.

The hazard map, shown in Fig.3, presents the livestock pressure in the region. It reveals the “very severe” condition of degradation hazard in most parts of the west, center and south east in Khuzestan province, which is only about 33.34% of the total area (Fig. 4). The “Severe” condition of degradation hazard is observed in 6.96 % of total area. The high pressure at these regions is related to both lower potential of forage production and numbers of livestock.

The “Moderate” degradation hazard conditions are observed in 1.83 % of the total area, which covers only small parts of the area. The hazard map shows most parts of the province (about 58%) belong to the least hazardous condition covering more mountainous area and agricultural land.

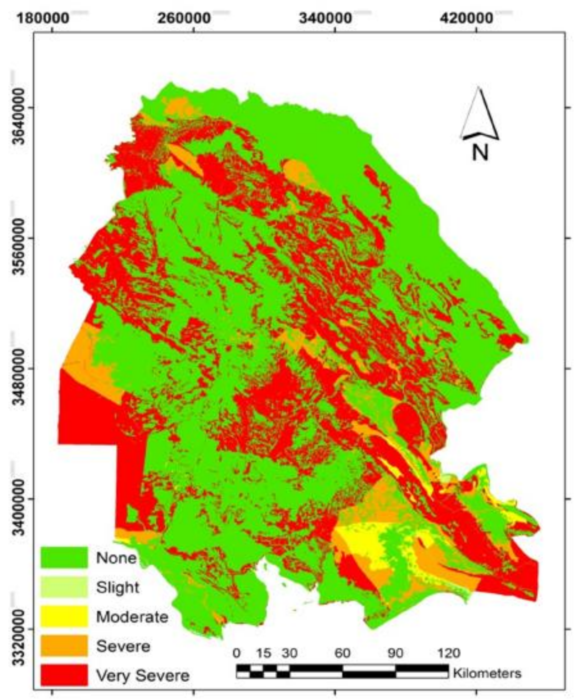

Fig. 3. The hazard classes of livestock pressure in the region.

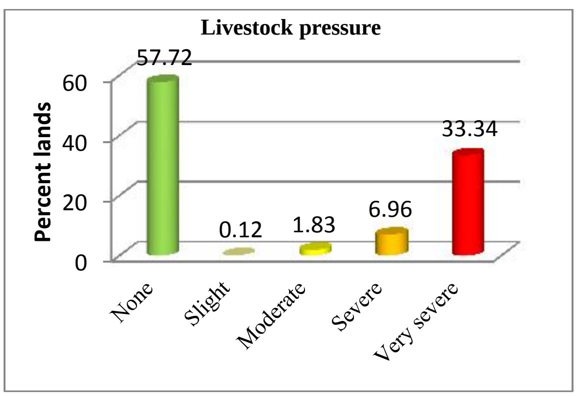

Fig. 4. Percentage of land under different hazard severity classes of pressure of livestock in Khuzestan province

In this method, the hazard class of non-natural resources lands like garden, farm and residential lands is assigned none or with no risk. If we consider the expansion of hazard classes just in natural resources lands, the percentage of severe and very severe classes has increased. According to this viewpoint, the “severe” and “very severe” conditions of degradation hazard are observed in 70 % of total natural resources area. This result is in good agreement with other results regarding livestock pressure in different regions of Southern parts of Iran indicating high pressure is observed on the natural resource area (Masoudi et al., 2005; Masoudi and Asrari, 2006; Amiri et al., 2008). The percentage graph of natural resource lands under different hazard severity classes of pressure of livestock in Khuzestan province is presented in Fig 5.

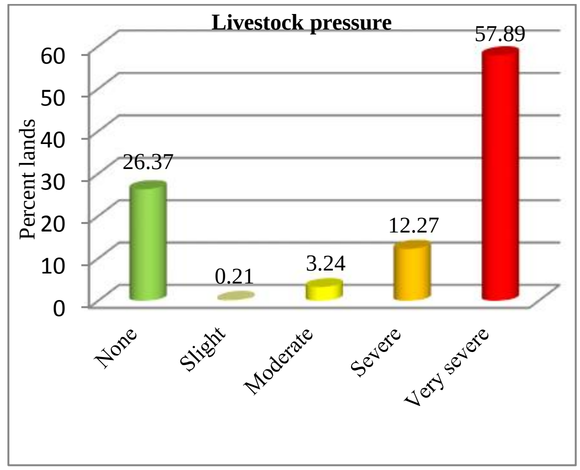

Fig. 5. Percentage of natural resource lands under different hazard severity classes of pressure of livestock in Khuzestan province

The FAO/UNEP model was modified in this study to achieve a better estimation of pressure index according to the actual conditions of the region. Parameters which were used to modify this methodology were: Topographic and Local parameters. A ratio and classification of potential carrying capacity to present livestock density by FAO/UNEP (1984) method can be adopted for assessing livestock pressure in this region.

Local parameters, which were used to modify the method were: annual consumption for livestock unit in the study area, number of livestock units for each animal, dependency of each livestock to pasture and land use map. The last two parameters were not used in the FAO/UNEP model. Other works in Iran also suggested using these parameters to achieve more real results about livestock pressure (Research Institute of Planning and Agricultural economics, 1998; Natural Resources Bureau of Fars Province, 2003; Amiri et al., 2008). So, the study employed criteria for assessing animal pressure, which are not universal and were elaborated on the basis of the local conditions.

Topography can be one of the effective factors in livestock pressure. In low elevation and gentle areas, easily accessible topography, the shrub steppe site likely received the greatest grazing pressure of all our sites (Masoudi, et al., 2005; Masoudi and Asrari, 2006). Seasonal migration to make use of natural resources at different altitudinal belts is a basic feature of Tibetan-style transhumance in the Hengduan Ranges of China. In this production system, resources in alpine areas are often underused while low-elevation resources are seriously overused. Low-elevation shrubs and the capacity to provide supplements in winter time are the bottle-neck in successful livestock production. A shift in grazing activities to areas at low elevations has increased the pressure on already fragile ecosystems and intensified shortages of fodder in winter. The ecological and socioeconomic consequences of such changes need to be closely monitored (Shaoliang et al., 2007). Therefore, due to the different livestock pressures in mountainous, plain, and hilly areas, evaluating the livestock pressure in order to calculate the more accurate ADL in the altitude mountainous ranges and plains can help us to increase the accuracy and attain better results. So, the hazard classification performed with GIS model showed high accuracy if topographic and local aspects are considered.

CONCLUSIONS

Hazard analysis of livestock pressure is a prerequisite to conserving and improving natural rangelands. Conserving and reclaiming rangeland in Southern Iran, highly threatened by overgrazing, is the need of the day. Hazard map using different data in the GIS together gives a far better opportunity to distinguish severity classes of livestock pressure. The study employed criteria for assessing animal pressure which are not universal and were elaborated on based on the local conditions. A ratio and classification of potential carrying capacity to present livestock density by FAO/UNEP (1984) method can be adopted for assessing livestock pressure in this region. However, some modifications, based on the local data, are needed to achieve a better estimate of the pressure. Local parameters which were used to modify the method were: annual consumption dry matter for livestock unit, livestock dependency on natural rangeland and number of livestock unit for each animal. Moreover, due to the different livestock pressures in mountainous, plain, and hilly areas, evaluating the livestock pressure based on topography condition in order to calculate the more accurate ADL in the altitude mountain range and plain can help us to increase the accuracy and attain better results. The hazard map shows that the areas under severe and very severe classes cover about 40% of the study area.

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ارزیابی خطر فشار دام در استان خوزستان، ایران

مریم الهایی سحر، مسعود مسعودی*

گروه مهندسی منابع طبیعی و محیط زیست، دانشکده کشاورزی، دانشگاه شیراز، شیراز، ج. ا. ایران.

*نویسنده مسئول

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چکیده- چرای بیش از حد، تخریب خاک و پوشش گیاهی در مراتع را افزایش می دهد. در این مطالع ارزیابی فشار دام در منابع طبیعی استان خوزستان، که در جنوب غربی ایران واقع شده است با استفاده ا سیستم اطلاعات جغرافیایی (GIS) و یک مدل انجام شد. بدین منظور از مدل فائو-یونپ که بر اساس نسبت ظرفیت برد بالقوه منطقه به تراکم فعلی جمعیت دام ، فشار دام را بررسی می نماید استفاده شد. ب این حال، به منظور دستیابی به ارزیابی بهتر فشار دام با توجه به شرایط واقعی منطقه اصلاحاتی روی ای مدل صورت گرفت. پارامترهایی که برای اصلاح روش استفاده شد عبارتند از: پارامترهای توپوگرافی محلی. پارامترهای محلی شامل مصرف سالانه واحد دامی در منطقه مورد مطالعه، وابستگی هر دام به مرتع تعداد واحد دامی برای هر حیوان و نقشه کاربری اراضی بودند. نقشه خطر فشار دام پس از همپوشانی محاسبه پارامترهای مختلف در GIS تهیه شد. با توجه به نتایج، کلاس خطر شدید و بسیار شدید حدود ۲۰ درصد از منابع طبیعی در منطقه مورد مطالعه را شامل می شود. طبقات با شدت خطر بالا بیشتر در مناطق غرب، مرکز تا جنوب شرق منطقه مورد مطالعه مشاهده شد. این مسئله به دلیل پتانسیل کم مراتع طبیعی در رشد کافی علوفه و همچنین وجود تعداد زیادی از دام در این مناطق می باشد.