SUSTAINABLE SHEEP GRAZING BASED ON RANGE SUITABILITY CLASSES

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Abstract: Rangelands are complex ecosystems with balanced and accurate relationships between its parts. Correct management of these ecosystems needs enough knowledge of various parts to be able to consider their capability for suitable utilizations in each region. Range suitability and its grazing capability are the most important criteria in rangeland analysis and monitoring. Recognizing factors affecting range suitability and diagnosing them is important. All range ecosystem components affect range suitability; however investigating all factors is impossible. So, physical factors and vegetation's role in the creation of the sub-models including yield, water resources and soil erodiblity were considered. This research has been done in Sorkhabad watershed located in south-west of Pole Sefied city in Mazandaran province. The framework of this research was based on F.A.O (1991) method for land evaluation assessment. For determining the soil erodiblity model the EPM model was used. In terms of range production suitability, proper use factor was determined based on the soil erodiblity class, range condition and range condition trend. Then production suitability was determined based on available forage to animals. Water quality, water quantity and distance of watering points were integrated to create water suitability sub-model. Sub-models of soil erodiblity, forage suitability and water resources formed the final suitability model using GIS. According to the results 23.63% of the rangeland area was classified as high suitable (S_1), 33.91% as having moderate suitability (S_2), 26.5% as low suitable and 15.98 % as being non suitable (N). Limiting factors of soil suitability was sensitivity of soil to erosion, also limiting factors of low available forage was because of that available forage was affected by soil suitability through small utilization level. There were no serious problems in terms of water resources; only in some areas distance of water resources and high slope (>60 %) caused limitation in water resource accessibility. GIS facilitated integration of information within and between models. Among all land characteristics, slope and erosion were the most important factors in reduction of range suitability for sustainable sheep grazing. Utilization of rangeland based on grazing capacity, range readiness and rehabilitation of degraded areas can improve suitability of rangelands in the region for their sustainable utilization.

Keywords: GIS, Range suitability, Sheep grazing, Sorkhabad catchment, Sustainable utilization

INTRODUCTION

Correct management of rangelands requires information from various parts of the ecosystem to recognize their capability for suitable utilizations. Range suitability assessment can facilitate sustainable management planning for these resources.

Grazing management has been the primary theme of rangeland management. Grazing by domestic and wild animals, is an integral process in practically all rangelands (Quirk 2002).

In all rangelands, grazing will continue to be an important process, and grazing management is important to those are interested in the sustainable and productive use of rangelands. Sheep among other types of domestic livestock is dominant in the study area. Grazing on the slopes of more than 60% because of animal performance reduction, also grazing on rangelands with more than 5 km distance from watering points is not economical. In addition grazing on rangelands with soil sensitive to erosion will cause land degradation. Therefore classification of range suitability is necessary for range sustainable management (Arzani et al. 2005).

According to FAO (1991), extensive grazing by domesticated animals and animals is the predominant form of land use on at least a quarter of the world'. So grazing evaluation must include production of both grazing forage, as primary production, and the amount of livestock feed on this forage, as secondary production.

Ibrahim (1975) has defined suitability as the adaptability of an area to the grazing of livestock or game. FAO (1991) stated that a land evaluation must asses the consequences of applying each proposed land use as accurately as possible, so that only those that can be sustained without long-term degradation of the land may be considered for implementation when determining land suitability. All major land use types require certain environmental conditions (land use requirements), in order to be successfully practiced. Adequate forage and access to watering points are examples of land use requirements for animal grazing.

GIS will help accurate integration of information to classify range suitability for grazing.

The objectives of this study were: (a) To understand the most important factors affecting range suitability for sheep grazing in the study area. (b) To recognize limiting factors for sheep grazing in the area. (c) To introduce a model for assessing range suitability for sheep grazing. (d) To classify studying area's suitability for sheep grazing.

METHODS

Sorkhabad catchment in Mazandaran province was selected for study. It is a humid region with an area of 2349 hectares, located between 52°52´57" to 52°47´54" east longitude and 35°55´47" to 35°59´05" north latitude in Alborz Mountains. Its average annual precipitation is 429 mm with average slope of 40%. Climatic condition is cold- humid according Amberje model. Its soil is erotic regosol. Rangeland includes 94.78% of the area (2226.83 ha). Six vegetation types were recognized in the region (Watershed plan, 2001) illustrated by figure 1. Production in each vegetation type was measured using clipping and weighing method within 8-10 1^2 meter quadrates along 4 100 m transects. Production suitability was determined based on available forage (table 1). The areas with lower than 150 kg dry matter per hectare were considered as non suitable for grazing.

The Method introduced by FAO (1991) was used for range suitability assessment using ILWIS version 3.2 and Arc/Info 324 as GIS soft wares.

Two orders of range suitability for sheep grazing were considered: suitable (S) and not suitable (N). Suitability (S) was divided to three classes of highly suitable (S1), moderately suitable (S2), and marginally suitable (S3).

EPM model (Ahmadi, 1995) was used to produce erosion sensitivity class's map in erosion suitability sub-model (Figure 2).

In forage sub-model, information was integrated for each vegetation type using below formula.

DLNN = GP + T + FQ

Where DLNN= daily livestock requirement, GP= grazing period, T= topography, and FQ= forage quality (Arzani, 2009).

Based on forage quality and animal unit live weight (31 kg for Zel sheep breed) and MAFF (1984) equation the daily demand of animal to dry matter forage for maintenance condition in keeping yard was determined, and then 50% was added for grazing on rangeland because of topography and environmental condition of study area (Nicoll, 1987). Water demand during grazing period was determined after calculation of grazing capacity. One of the processes for grazing capacity determination was calculating available forage to livestock using the formula of;

AF= Σ(Y+ (P/PUF))

Where AF= available forage, Y= yield (kg/ha), P= palatability, and PUF= proper use factor. PUF was determined considering range condition trend and erosion sensitivity information. Finally suitability of forage was classified by integrating the information mentioned above based on table 1. The procedure has illustrated by (Figure3).

Water resource sub-model included quantity, quality and accessibility of water information. Slope and distance maps were integrated to create accessibility to watering points map.

Table 1: Range production suitability classes based on available forage to forage production ratio in Sorkhabad catchment.

Percentage of available forge from total production	Degree of suitability
40-50	S_1
30-39	S_2
20-29	S_3
<20	N

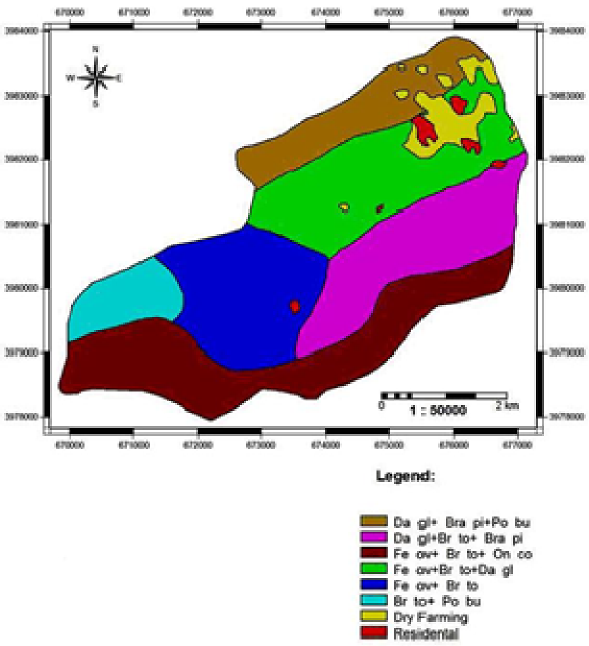

Figure 1: Vegetation map of Sorkhabad catchment

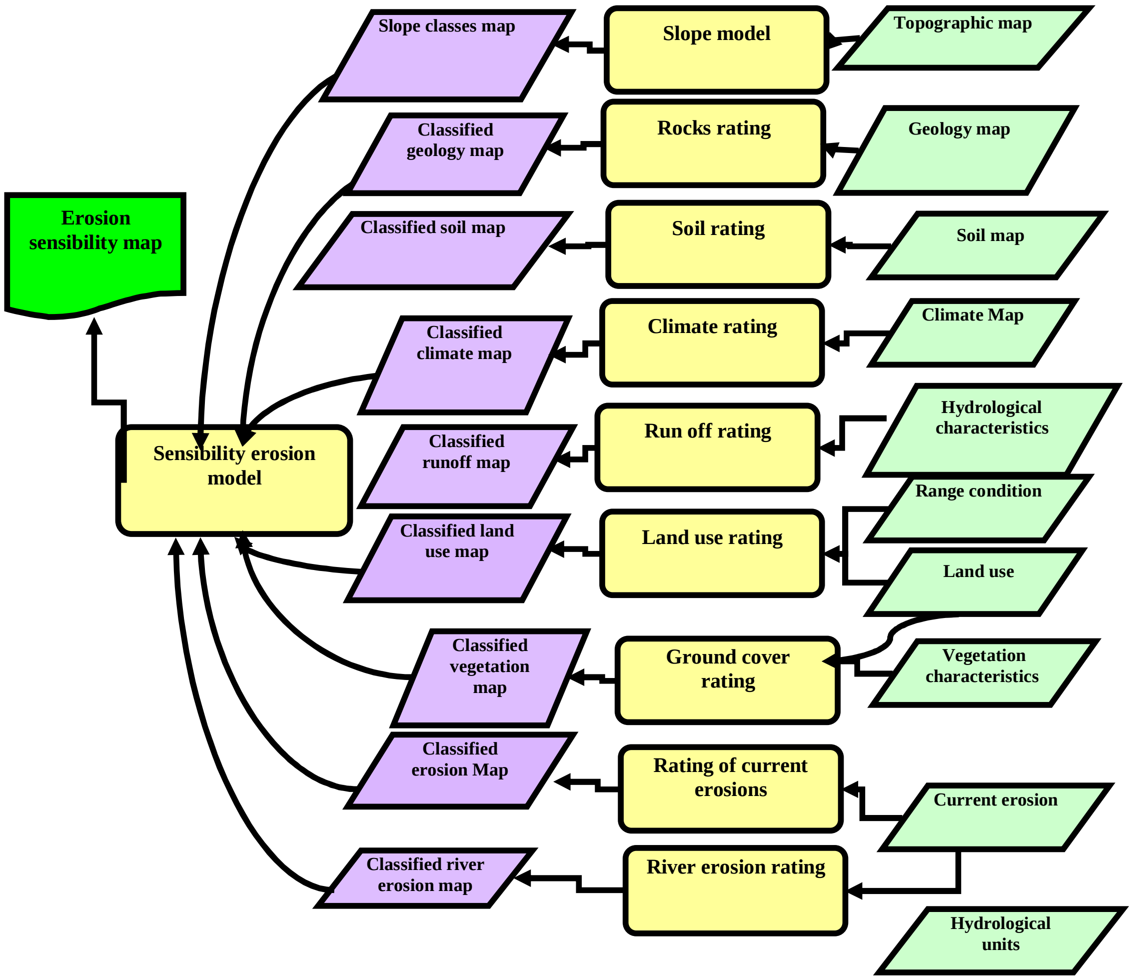

Figure 2: Model for classification of erosion suitability

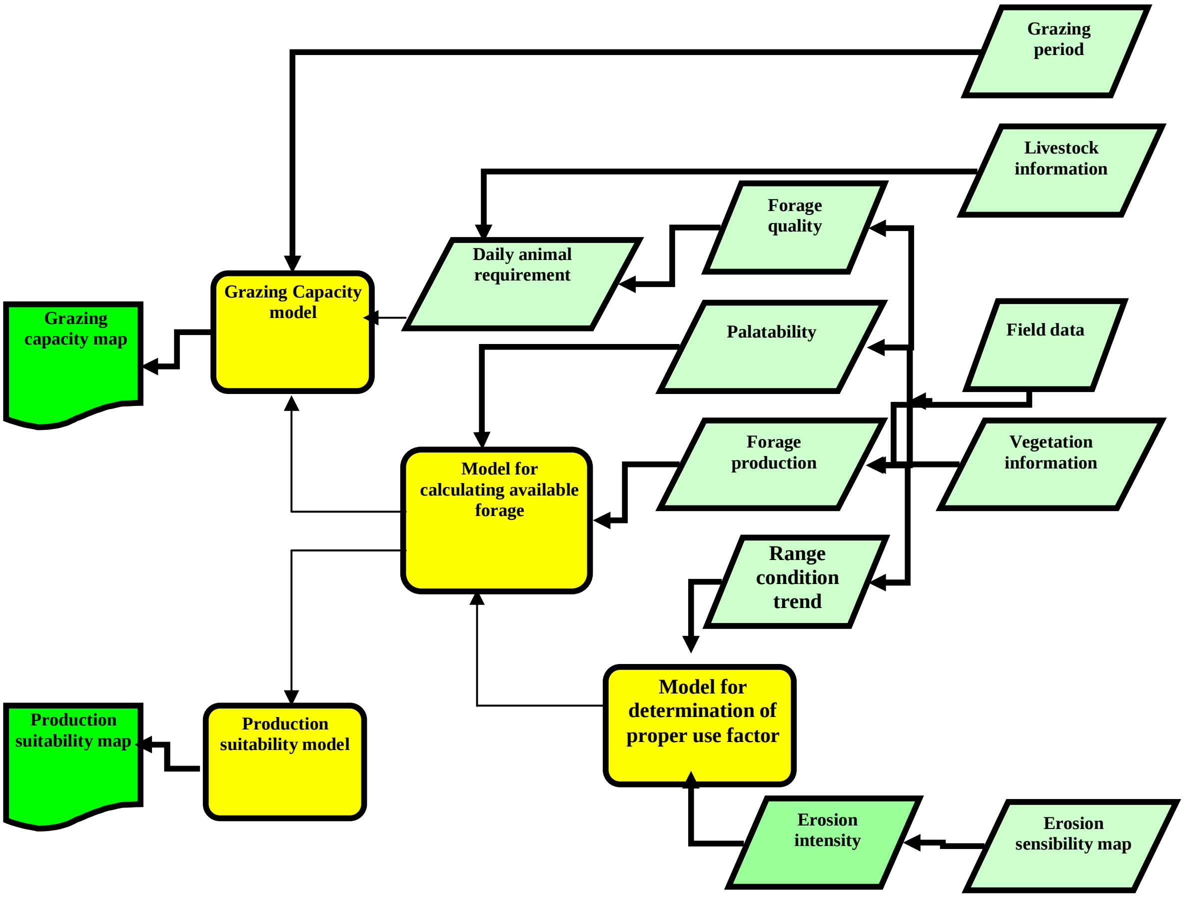

Figure 3: Model for classification of production suitability and calculating grazing capacity

Table2: Water resource distance (meter) and its suitable classes

Slope class (%)	0-8	8- 20	20- 60	>60
Suitability class				
S1	0- 3400	0- 3000	0- 1000	N
S2	3400- 5000	3000- 4800	1000- 3600	N
S3	5000- 6400	4800- 6000	3600- 4100	N
N	>6400	>6000	>4100	N

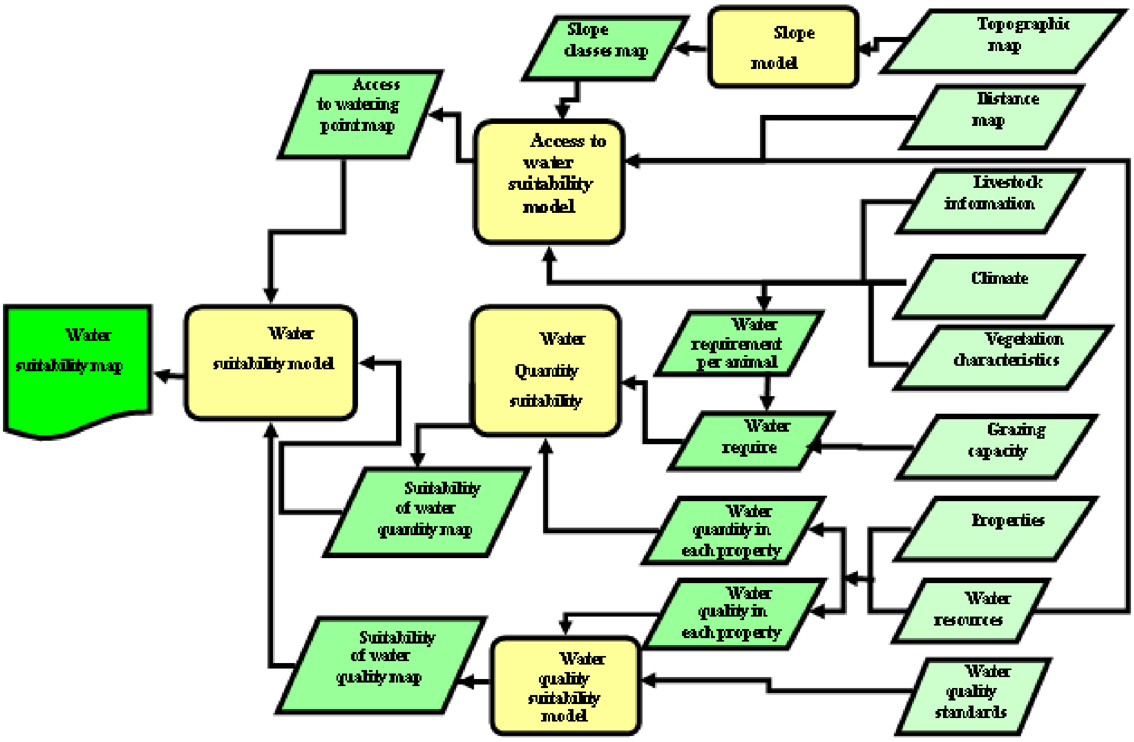

Figure 4: Model for classification of water resources suitability

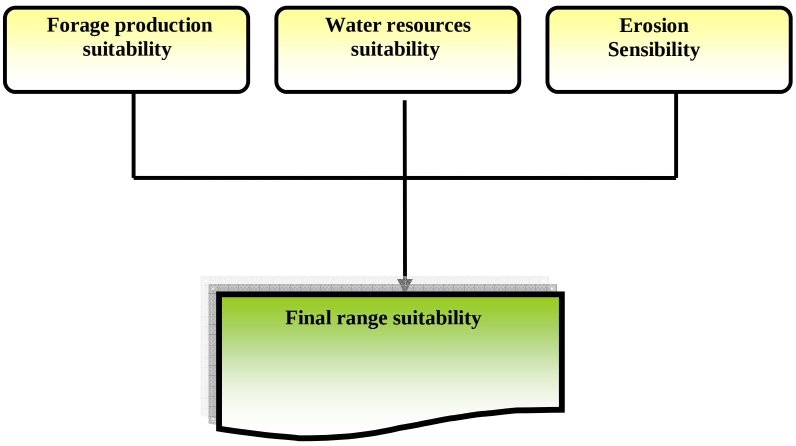

Figure 5: Model for final range suitability classification

Quantity of water was evaluated by considering the grazing capacity and water requirements per animal. Table 2 shows suitability level of distances according slope classes. Water quality was assessed by laboratory analysis of water in terms of EC, TDS[1], and Mg. Final range suitability model of water resources was created by the combination of sub-models for producing a water suitability map for sheep grazing (Figure4). Outputs of erosion, water and forage sub-models were integrated to create range suitability classes (Figure 5).

RESULTS

Generally rangelands in Sorkhabad catchment had a high potential for grazing. Annual precipitation is good. No limitation for water in the catchment, palatable species had good frequency and climate condition is desirable for plants growth. However there are some limitations for grazing too.

In terms of sensibility to erosion, no part of the area was classified as N suitability class, 43.9% of the area was resistant to erosion and classified as S1, 21.04% was located in the S2 class (Low erosion) and 35.06% were classified as S3 class of soil suitability (Table 3 and Figure 6).

Investigation on water resources showed that the limitation factor of potable water in the mountainous areas is slope. However in terms of quantity and quality of water the suitability class was S1. When three sub-models of water were integrated, 1586.78 ha of the area contained S1, 284.4 ha was classified as S2, and 355.65 ha because of slope of more than 60% was located in the N order (Figure 7).

In terms of forage production, vegetation types were classified as S1 and S2, none of vegetation types were classified as nor S3 or N. There were about 1081.71 hectares (48.58%) with good suitability (S1), about 1145.12 hectares (51.42%) with moderate suitability for sheep grazing (S2). Vegetation types of 3, 4 and 6 were located in S1 class and vegetation types of 1, 2 and 5 were distinguished as S2 class (Figure 8). Integration of three sub-models of sensitivity of soil to erosion, water resources and forage based on FAO (1991) method showed that there are 526 hectares rangeland with S1 class, 755 hectares of rangelands with S2 suitability class and 590 ha in the S3 class and 355.5 ha in the N order (Figure 9). Without GIS it was not possible to integrate information layers within and between models accurately.

DISCUSSION

As FAO (1991) cited land characteristics required for successful utilization are considered as requirements of a kind of land utilization and known as land quality. Each land quality is determined by interaction of several land characteristics. Requirements and limitations of a type of utilization is the base of decision making for range suitability classification. Soil erosion sensitivity, forage production and water resources are the main three factors affecting range suitability for sheep grazing. In each region these factors depends on climatic conditions, vegetation cover, soil, conditions of the current land utilization and topographical conditions however the form of range suitability model may be different. The model will introduce limitation and advantage factors of grazing suitability of the areas.

There are some limiting factors in each sub-model of erosion, water resources and forage production that may affect range suitability for sheep grazing. Animal grazing would cause soil and vegetation cover degradation in the areas with sensitive soil to erosion. According to the results of the erosion model the most limiting factors in the area were slope and types of land utilization (changing rangelands to dry farming). The average percentage of slope in the area is 40% which is the main reason for being S3 class of suitability. However species such as *Astragalus sp., Onobrychis cornuta, Berberis sp.* and *Artemisia aucheri* protect the soil and make it stable. In addition high vegetation cover percentage including grasses, forbs, shrubs and trees and desirable precipitation decrease sensitivity of soil to erosion. Slope had negative relationship to soil dept. So the soil depth was lower in sloping areas as was reported by Refaei (2000). Livestock grazing also had effects on soil erosion. Early and sever grazing have been caused degradation of vegetation cover and trampling of soil. This was also experienced by Arzani et al. (2006) in their studying areas.

Sufficient precipitation and existence of perennial grasses, forbs and shrubs in vegetation composition were the advantage factors of suitability classification and reduced soil erosion in some parts of the catchment. In terms of forage production, all rangelands were suitable for sheep grazing because of suitable climatic conditions. The most important factor that reduced forage production suitability was the value of the proper use factor which was affected by sensitivity of soil to erosion. Range production was not a limiting factor for grazing in the area. The highest proper use factor was determined for vegetation type with good condition and sustainable soil (50%). There was no vegetation type with poor condition however there were some vegetation communities with fair conditions and moderate to high soil erosion.

[1] Total Dissolved Salts

Table 3: Soil suitability classes of Sorkhabad catchment

No	Suitability class	Area (hectare)	Percentage
1	S1	977.60	43.9
2	S2	468.60	21.04
3	S3	780.63	35.06
4	N	0	0
Total		2226.83	100

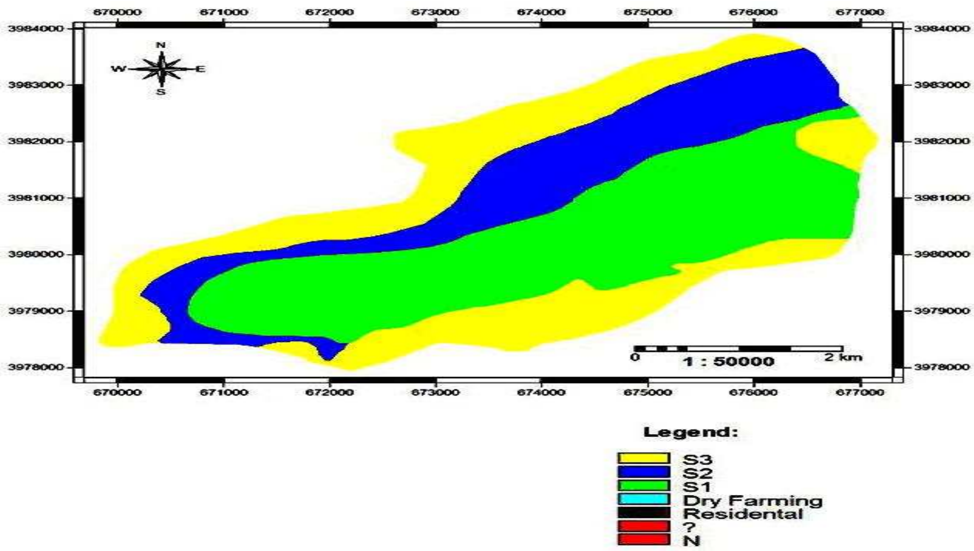

Figure 6: Erosion classes of Sorkhabad rangelands

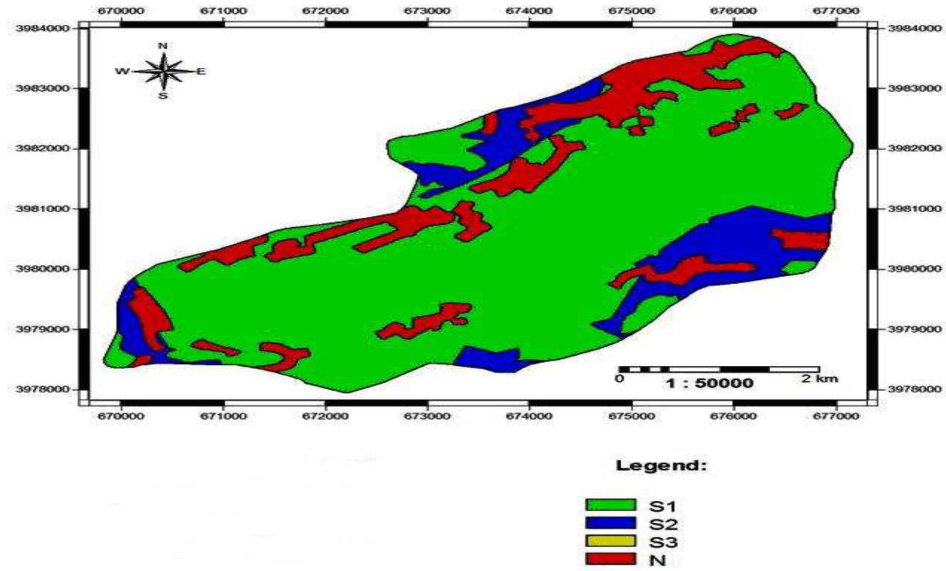

Figure 7: Water suitability map of Sorkhabad catchment

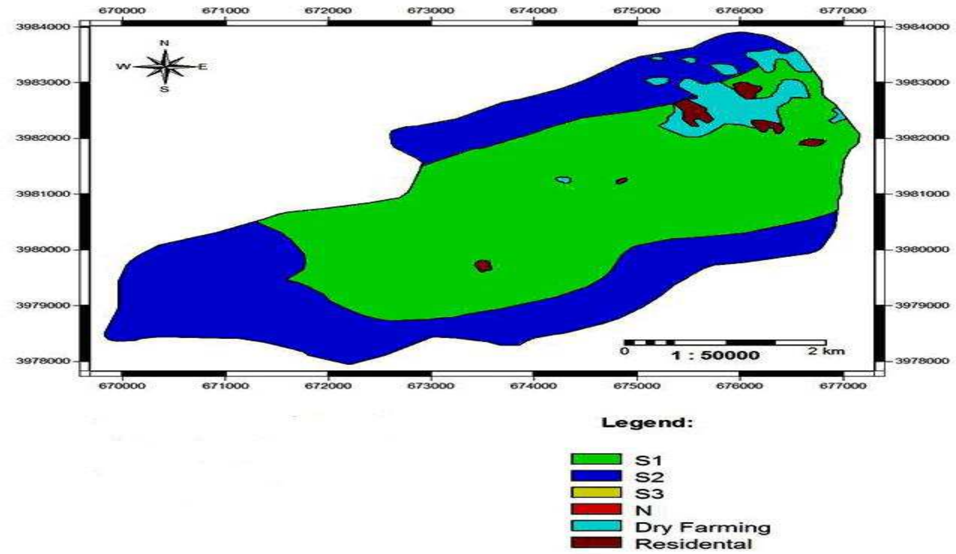

Figure 8: Suitability map of forage production in Sorkhabad catchment

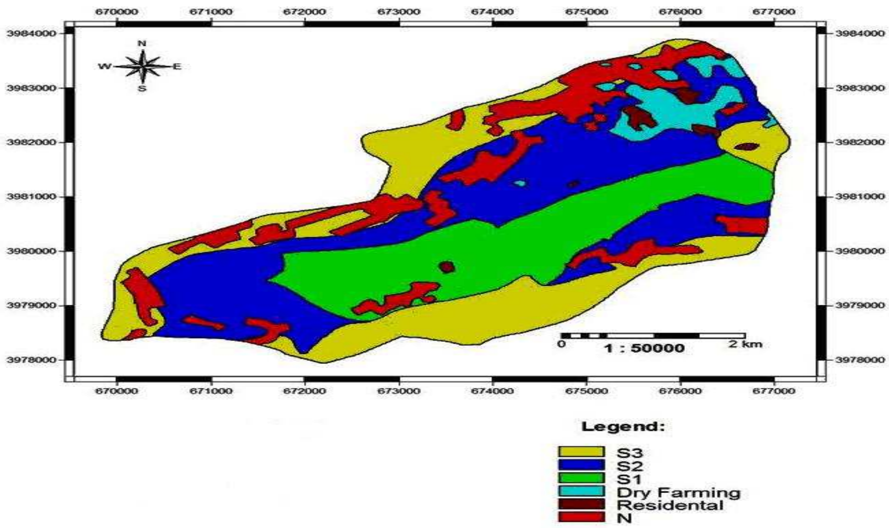

Figure 9: Final Range suitability map of Sorkhabad rangelands

There was no limitation in terms of water quantity and quality in the area. The only problem was difficulty of water accessibility in sloppy areas that was also reported by Fashtami (2002) in his study areas. So no grazing is recommended for sloppy areas by domestic animals. These areas can be considered just for wildlife and tourism. The problem of accessibility to watering points also was reported by Yousefi (2004) for the rangelands of Taleghan in another part of Alborz Mountain. Therefore slope is important for water suitability classification in the area. Holechck et al. (1998) believed that domestic animals should not graze on slopes of more than 60% because of the consumption of the energy obtained from forage by movement on the slope. He also believed that wildlife is suitable for grazing on sloppy areas.

In the final range suitability classification for sheep grazing based on most limiting factors among sensitivity of soil erosion, forage production and water resources, slope of more than 60% was reduced accessibility to watering points and increased sensitivity to erosion. While soil and production, should be considered as factors reducing range suitability classes in the area. So limitation of grazing is not serious in the region if sever and early grazing be controlled. Curran and Grice (1992) suggested grazing management can be a solution. Also range manager should apply appropriate grazing systems which cause reduction of undesirable species in vegetation composition. This study was focused on suitability of rangelands for sheep grazing, but as Holechek et al. (1998) stated significant income from rangelands can be derived by selling products rather than livestock. Further investigation can be done on the multiple uses of rangelands in the area as was also suggested by Grice and Hodgkin son (2002).

A GIS can provide better information and easier integration of various information layers to support model of range suitability assessment. It found to be a useful technique to provide greater flexibility and accuracy for range suitability assessment.

Generally determination of range suitability is an important and difficult task in range management. It is important to distinguish effective factors of reducing and increasing range suitability level. As the factors may differ depends on climate and environmental conditions. So the application of the model in other areas should be done with care.

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