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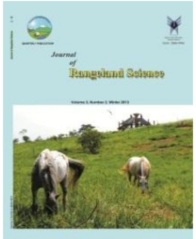

Full Length Article:

Identifying Rangeland Development and Restoration Operations Targets (Case Study: Hossein Abad Bazoft Basin, Chaharmahal and Bakhtiari Province, Iran)

Azadeh Afrigan[A], Mohammad Jafari[B], Arghavan Shahlayie[C], Sara Jamalpour[C]

[A]M.Sc. Grad. St. Dep. of Rangeland Science and Research Branch, Islamic Azad University Tehran. Iran. (Corresponding Author). Email: a.afrigan@yahoo.com
[B]Professor, Faculty of Natural Resources, Agriculture & Natural Resources University of Tehran, Tehran, Iran.
[C]M.Sc. Grad. St. Dep. of Rangeland Science and Research Branch, Islamic Azad University Tehran, Iran.

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Abstract. The purpose of this study was identifying rangeland development and restoration operations targets. This study was conducted in Hossein Abad Bazoft basin with 7162 ha area, located in south east of Farsan County, Chaharmahal and Bakhtiari Province, Iran. The basin has various land uses including rangeland, forest, irrigated farm and garden, dry farm, residential area and rock mass. In this study, during land surveying process, ecological carrying capacity was first calculated for the rangelands and forests ecosystem. After capability evaluation, with regard to keeping the current land use and avoiding from more land degradation, restoration programs were proposed. In this regard, required data layers including altitudinal classes, slope classes, aspect classes, rangeland condition and trend, climate, soil hydrologic groups, depth and texture of the soil, geology and geomorphology were overlaid using GIS 9.3 by intersect method, and 280 homogenous units were resulted. The results of homogenous unit characteristics assessment showed that the region fell respectively in the categories 1, 3, 6, 3 and 4 for conservation, rangeland, forest, agriculture and unauthorized agriculture capabilities. Finally, according to the characteristics of the achieved capabilities and defining required criteria to propose each executive program, we proposed the location and the kind of the executable restoration programs such as exclosure, hill seeding, converting the inefficient dry farms to forage plants cultivation and in forest quantitative and qualitative regeneration.

Key words: Artificial method, Restoration, Rangeland and Forest, Development, GIS

1. Introduction

Rangelands are one of the most important renewable resources and at the same time one of the most precious natural asset of each country, having very valuable role in animal, pharmaceutical, and industrial productions, air purification, water and soil conservation (Akbarzadeh and Razaghi, 2002). They are considered as the context of human life and economic sustainability (Khalilian and Taheri, 2001).

Therefore, appropriate range utilization and management, having dynamic nature, requires assessment and classification of ecological-environmental carrying capacity and socio-economic condition depended on them. Therefore, it can be possible to identify current capabilities and limitations of the rangelands and the society to the separating controlling factors and variables, and reduce the limitations and improve capabilities in order to optimize the efficiency through restoration operations, development and extension, and predict their future capabilities (Makhdom 1999; Onegh, 1997). In this context, GIS as a tool plays an essential role in data analyses and presenting accurate results for range management and planning (Gharedaghi, 1998). In the context of forest modeling and evaluation in Iran, Babaie Kafaie (2006) performed the environmental assessment using GIS in order to classify forest lands of Kazemrood basin in Mazandaran province, Iran North Forests.

Rangelands are the most vast ecosystem on the Earth, making up close to half the terrestrial global landscape (Moghadam, 2007). As well as producing and providing forage for livestock, rangelands possess other benefits including soil conservation, infiltration, underground water recharge, avoiding sediment entrance to the reservoir, floods reduction, air purification and possible damages, and animal and plant species protection (Azarnivand and Zare Chahooki, 2008). The more important is to determine degraded sites and threatened species and ecosystems in order to execute the suitable conservative, supportive, restoring and rehabilitating operations in the ecosystem level based on the knowledge resulted from resource analyses, and to restore ecosystems to the sustainable ecologic state and natural areas climax (Azarnivand and Zare Chahooki, 2008). Mohebi and Gholami (2009) applied GIS to provide base maps and digitize and incorporate them through systematic approach based on designed model for monitoring Til Abad basin in Golestan province, Iran. Zarei *et al*. (2009) assessed environmental capacity of arid and semi-arid Birjand watershed, South Khorasan province, Iran by overlaying layers in GIS. Final environmental units map and the map of the environmental carrying capacity were achieved by incorporating five maps: geographical aspects, slope, elevation, land use components, vegetation and considering the ecological, climatic, demographic and hydrologic properties. Ghasemi Arian (2010) used GIS to identify suitable sites for executing rangeland improvement and restoration operations programs and also livestock water resource management in Chahtalkh basin, southwest Sabzevar, Iran. He determined suitable sites for restoring operations in the region by overlying base maps in GIS (including iso-rain, slope, rangeland conditions, rangeland suitability, land use, soil texture and depth) and defined required criteria for proposing a restoring program. At the end, restoring operations, contour- furrow operations, pitting, ripping, grazing management and enclosure were proposed in the final model. Zabuli *et al*. (2010) used GIS to determine the potential habitats of *Haloxylon* sp. in Sistan region, Iran.

In the context of rangeland modeling and evaluation in other countries, Zhou (1989) innovated a convenient method for evaluation, measurement and modeling of rangelands fertility using land resources information system and integrating GIS and RS in the state of New South Wales in the arid part of Australia. Lee *et al*. (2002) identified natural forest production and improvement sites in Chiltern Hills, England. In this regard, forest with 20 and 50 ha area were considered as the core of identifying sites and the lands close to the cores were identified as the land suitable for seedlings plantation, and classified according to the research objectives. Their results showed that GIS was a suitable tool for sites restoration and it was more profitable than other approaches. Similar studies in this field were conducted using GIS by Wang and Chen (2000) in order to identify appropriate sites for planting the tree species *Taiwania cryptomerioides*, Lesher (2005) to identify potential habitats of *Hypogymnia duplicate*, Rubio and Sanchez (2006) to determine appropriate sites for introduction and rehabilitation of *Fagus sylvutica*. The land monitoring map was prepared after determining carrying capacity of the region. Kumar *et al*. (2008) also used RS and GIS to identify the appropriate sites for implementing rainwater harvesting techniques in Uttar Pradesh, India.

Due to the high cost of implementing rangeland restoration operations and potential assessment of the region, identifying the exact location of these operations is of principles and initial cases that could be greatly facilitated using GIS to determine the most appropriate sites and the best restoration method for rangelands. With regard to the aforementioned, this study was performed to identify rangeland development and restoration operations targets using GIS and present them as final restoring operations map; so that, future land use map could be prepared based on it for the region.

2. Materials and Methods

2.1. Study area

The research was conducted on the Hossein Abad Bazoft basin with 7162 ha located in south east of Farsan County, Chaharmahal and Bakhtiari Province, Iran. The region is located between 50°01'27" to 50°07'07" longitudes and 32°10'07" to 32°17'24" latitudes (Fig. 1). The elevation of the region ranges from 1400 to 4074 m above sea level. This area is characterized by 993 mm mean annual precipitation, and 17.6 ºC mean annual temperature. The mean monthly temperature ranges between 1.9 and 20.4° and, regional climate is very humid.

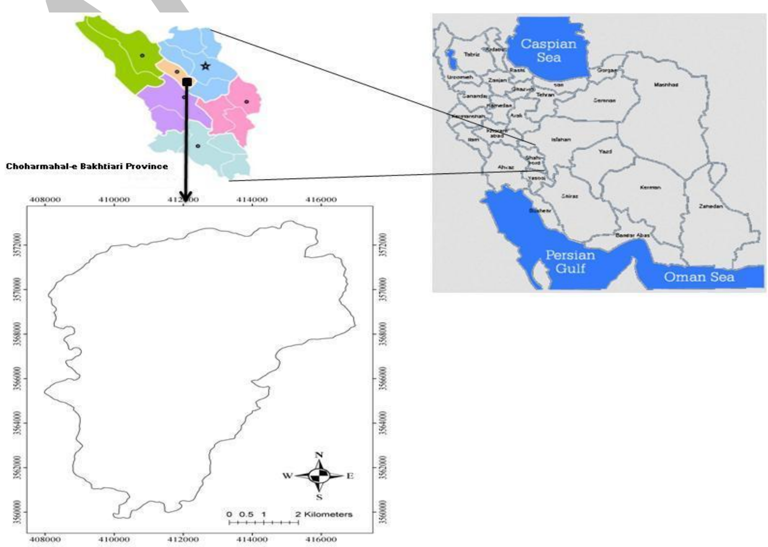

Fig. 1. Geographical situation of the study area

2.2. Research methods

1. Literature review, data collection, preparation of base maps: In order to conduct this research, based on objectives, information and reports about the study area were first investigated and initial visiting carried out in which ecological and environmental factors including weather, climate, slope, land use, vegetation, geology, soils and so on were assessed and required maps (topography, basin boundaries, geology, land use and soil) were prepared at 1:50000 scale. On the other hand, 1:25000 topographic maps (National Geosciences Database of Iran) were used to extract required parameters.
2. Land surveying based on Makhdoom's method: During land surveying process, the study basin was assessed in terms of ecological capabilities and with regard to the maintenance of existing land uses and to avoid more degradation (Fig. 2).

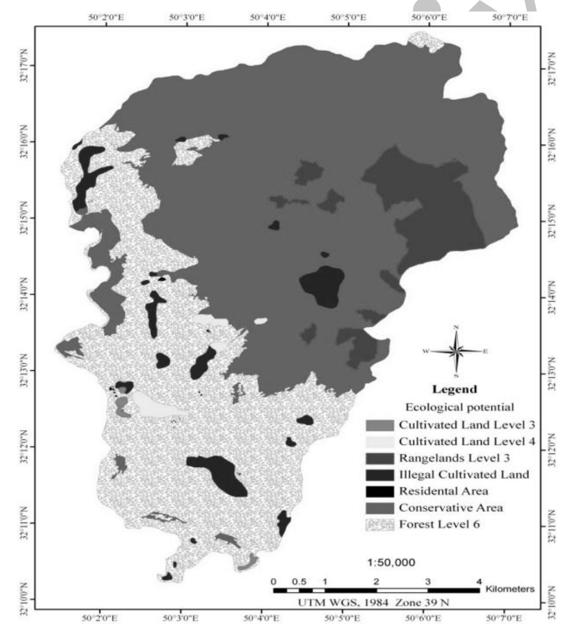

Fig. 2. Ecological potential map in Hossein Abad Bazoft basin, Chaharmahal and Bakhtiari Province, Iran

3. Mapping Digital Elevation Model (DEM): Based on digitalized contour lines in raster format in ArcGIS 9.3 environment: After preparing DEM through GIS and the 1:25000 topographic maps of the basin, the maps of slope classes, aspect and altitude were extracted from it.
4. Preparing Isothermal and Isohyetal maps: After obtaining the gradient equation from existing stations in the region, using this equation and DEM, Iso-therm and Iso-rain maps were prepared.
5. Geology and Pedology: Soil and geology data were extracted from available reports, executive study of Hosseinabad basin, and obtained data during field assessment.
6. Mapping vegetation condition: Using climatic and satellite data (aerial photo), during field survey, data were firstly collected. Data were secondly transferred to the initial 1:25000 map. The final separated units were then checked using 1:40000 aerial photos and Google Earth satellite images. Therefore, vegetation base map was prepared. Then using the land use map in which rangelands and forests had been segregated from other resources, and field survey, vegetation types were distinguished and separated using Kuchler and Zonneveld (1988) based on the degree of dominance of one, two or three species and their appearance. Relatively, homogenous vegetation units were identified and coded. After the initial diagnosis and types naming, the rough boundaries were drawn on 1:25000 map through field survey. Finally, the separated unit boundaries were checked using the information extracted from the altitude, slope and aspect of the first stage as well as the geology, geomorphology and soil information

in terms of the separated unit boundaries.

7. Incorporated maps using Makhdoom (1999) method: In the land use planning process, holistic view is the base (Makhdoom, 1999). In this study, to achieve this holistic view, the method of data incorporation for planning was evaluation of the potentials and limitations. Incorporating information through overlaying layers in the GIS (Ahmadi Mojarad, 1989 and Makhdoom, 1999) and extracting homogeneous ecological units for assigning to rangeland, managerial, biological and biomechanical operations were done by considering the potentials and limitations of environmental resources. In the evaluating and programming for the basin in rangeland and biological parts, the goal is to keep current land use as long as there are no restrictions on the interested land use (Makhdoom, 1999). Therefore, by adjusting Makhdoom systemic evaluation method (1999), potential and limitating factors were assessed with the current land use and the rangelands administration, development and restoration program were finally presented. In this assay, vegetation types and their coverage as well as soil structure and depth, elevation, geographic aspects, and slope had critical roles. In this regard, ecological information was classified and the program was present at the homogeneous ecological unit levels. Layers and information categories, used in the integration program based on adjusted Makhdoom method, are shown in (Table 1).
8. Determination of the type and location of the various restoration projects and adding their technical criteria: Management maps including exclosure management, hill seeding and forest qualitative and quantitative restoration were prepared. It's obvious that specific terms and conditions must be considered for each of these programs. Some of the important and essential factors such as precipitation, slope, and soil and so on are mentioned in (Table 1). Since other factors such as vegetation condition, soil, slope, aspect, temperature and so on as well as precipitation should also be considered to determine the suitable location for the programs execution, therefore other factors were applied on the maps with regard to the available criteria for each program, and the final restoring map was prepared.
9. Extracting the ultimate map of restoration and rehabilitation operations targets: Applying the model to identify rangeland and forest development and restoration operations targets.
10. Extracting the map of future land uses for the study basin (Fig. 4).

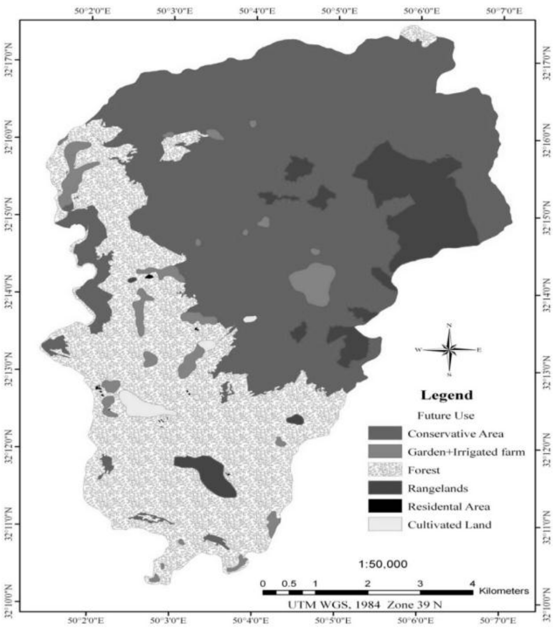

Fig. 4. Future land use map in Hossein Abad Bazoft basin, Chaharmahal and Bakhtiari Province, Iran

Table 1. Layers and information categories used in the integration program for determining (initial) resource suitability, biological and biochemical operation designing and management

Information Layers	The Number of Produced Categories	The Number of Categories in the Integration
Current land use	8	8 (rangeland, forest, dry farm, rock mass, residential area, garden, irrigated farm, bare land and debris)
Slope	8	4 (0-12%, 12-30%, 30-60% and <60%)
Elevation	27	5 (1400-2000, 2000-2500, 2500-3000, 3000-3500, 3500-4100)
Geographical aspect	5	2 (north and west are considered as a unit in contrast to south, east and lands with no aspect are considered as neutral factor in information integration
Stone and geomorphology	11	8
Soil and land resources	8	8
vegetation	4	4
Temperature	Continues in sub basin level	Mean temperature of in sub basin
Climate	Continues in sub basin level	Mean temperature of in sub basin
Precipitation	Continues in sub basin level	Mean temperature of in sub basin

3. Results

From 7162 ha of Hossein Abad Basin, according to the region carrying capacity, area assigned to each type of anticipated restoration operations is an a (Table 2).

Table 2. Carrying capacity, area assigned to each type of anticipated restoration operations.

Carrying Capacity	Exclosure	Exclosure and Quantitative Rehabilitation of Forest	Exclosure and Qualitative Rehabilitation of Forest	Hill Seeding	Range Seeding	Garden and Irrigated Farm	Dry Farm	Residential Area
Area(ha)	3866.2	1869.9	525.2	661.4	63.2	117.2	35.9	3.9

Considering the environmental condition of the region, management restoration operation programs were as follows:
The region range and forests restoration programs

3.1. Exclosure

The areas on which slopes were greater than 60 percent, rainfall was more than 200 mm, range condition was poor to medium, range trend was positive, invasive plants were rare in vegetation composition and the areas that included extensive rock mass faces (Azarnivand *et al*., 2007), were considered for exclosure with area about 3866 ha. Data layers used in the model included range condition, slope, geomorphology, soil, geology and precipitation, respectively.

A– Hill seeding

The project was proposed for areas that were mountainous or there was no possibility to prepare soil because of the susceptibility to erosion (in Marne), or didn't want to manipulating the natural vegetation. In these cases, seeds are planted among the other plats. Also, it is implemented in areas where rainfall exceeds 250 mm and desirable plants exist or areas where direct seeding is impossible because of being rocky and steep (Azarnivand *et al*., 2007). Data layers used to determine suitable sites for this program included iso-rain, geology, soil, slope, vegetation, and range condition, respectively. This program covered an area about 661.3 ha of the region.

B– Converting inefficient dry farms to forage plantation (hay dry farming)

It was recommended in areas where the soil depth was more than 15 cm; the slope was over 12%; and the average annual rainfall was about 250 mm with a good distribution (Ansari, 2009). Data layers used to determine suitable sites for this program included soil map, slope, vegetation, and range condition. This area included about 63.1 ha of the region.

C– Quantitative and qualitative rehabilitation of forests (forest restoration)

The two projects were recommended in mountainous areas with deep to medium deep soils, sandy-loam soil texture, slopes over 20%, and rainfall higher than 250 mm. Furthermore, amount of forest cover is respectively considered over and lower 25% for qualitative and quantitative restoration respectively. Data layers used to determine suitable sites for this program included iso-rain map, iso-therm, soil, geology, and vegetation. Quantitative and qualitative forest restorations occupied 525.2 and 1870 ha of the region, respectively. Finally the map of proposed program was developed using the criteria necessary to each kind of restoration operation (Fig. 3). The future land use map was developed by comparing the current land use map and ultimate map of restoration operation.

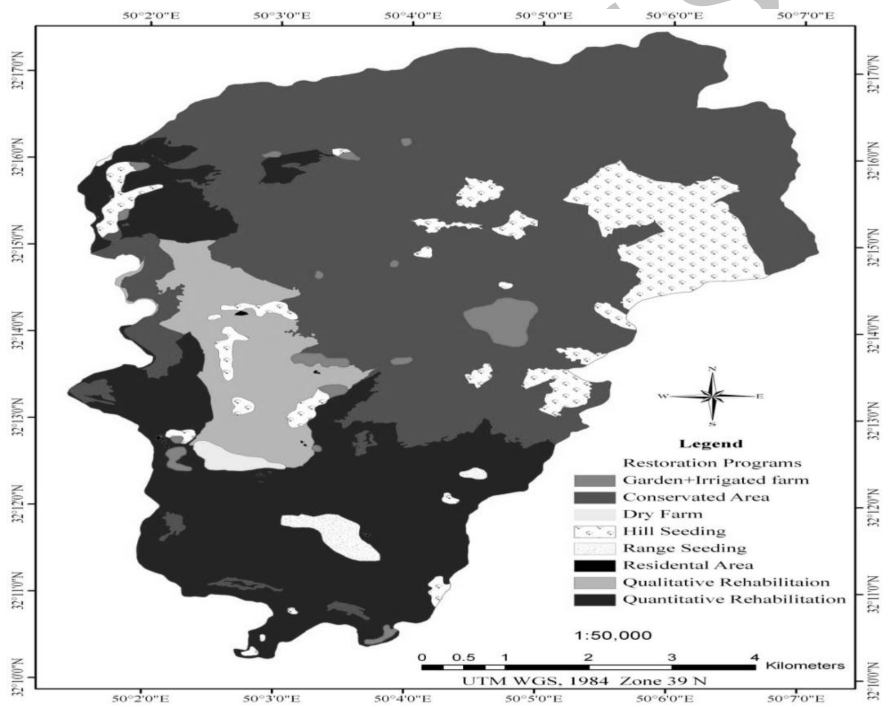

Fig. 3. Restoration programs map in Hossein Abad Bazoft basin, Chaharmahal and Bakhtiari Province, Iran

4. Discussion

According to the conditions of the region, the major programs for vegetation restoration and rehabilitation were hill seeding with 661.4 ha, rangeland hay seeding with 63.2 ha, qualitative enrichment of forests 525.2 ha, quantitative enrichment of forests 1869.9 ha, and exclosure with 3866.2 ha. Moghadam (2007) examined hay dry farming in poor rangelands of Taleghan. He concluded that the plant had largely contributed to the rangeland restoration and increased forage production over 1000 kg ha^{-1}. In the study area, it was assumed that the amount of forage production would increase over 250 kg ha^{-1} after restoration operation such as hill seeding. Gharedaghi (1998) suggested hill seeding in rangelands with poor or very poor condition, located on the slopes over 45%. The researcher proposed exclosure in the rocky lands and slopes over 65% where exposed to grazing. Also, in this manner, the grazing systems will not be considered unless rangeland condition improves to medium levels. Results of the vegetation study of this rangelands showed that the major parts of the rangeland were in poor condition with a negative trend. Azarnivand *et al*. (2007) stated that the selection of management and restoration operation type should be based on rangeland condition and ecological criteria so that appropriate management for such rangeland would be artificial. In this regard, the rangeland condition must be improved by artificial restoration and rehabilitation techniques. According to Valentine (1971), the restoration operations and their appropriate sites must be selected properly and carefully to be satisfactory. Therefore, the ecological conditions of the region should be considered to determine the restoration operations. GIS and data layers integration, based on required criteria for the restoration operations, could be useful in identifying rangeland development and restoration operations targets (Azarnivand *et al*., 2007). Azarnivad *et al*. (2007), Safari (2009) and Ghasemi-Arian (2010) provided a model to study rangeland management (respectively Taleqan, Lar and Sabzevar) using GIS. Also they comparise their results with Range plan for the proposed implemented. Finally, they concluded that the proposed method in comparison with manual design and quick and easy access to all of the data from this study and the greater transparency of information will result in quality control information. Also, all data from the study during their integration, preserve and refine errors and changes can be easily done all these things will increase the accuracy. Kumar *et al*. (2008) reported that GIS was useful tool in determining the location of they implement the appropriate methods to collect rainwater. Zabuli *et al*. (2010) in their study of the need to use new techniques to speed up recognize and manage the natural resources referred to in this regard known as GIS. Comparing current and future land use maps, changes in land use areas were as fallow: protected lands increased 2404.2 ha; dry farms decreased 174.4 ha due to unauthorized till; garden and irrigated farms decreased 30.6 ha due to executing hill seeding; rangelands decreased 1173.9 ha due to executing hill seeding and converting low efficient dry farms; forest decreased 1045 ha due to quantitative and qualitative enrichment and released lands added to the protected lands (Table 3).

Table 2. Comparing current and future land use

Future Land Use	Current Land Use	Project
2404.2	1462	Protected lands
174.4	210.3	Dry farms
30.6	147.6	Garden and irrigated farms
1173.9	1898.4	Rangelands
1045	3440.2	Forests

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مکان‌یابی عملیات اصلاح و احیاء مراتع (مطالعه موردی حوزه آبخیز حسین آباد بازفت- چهارمحال بختیاری، ایران)

آزاده آفریگان، دانشجوی کارشناسی ارشد، دانشگاه آزاد اسلامی واحد علوم و تحقیقات (نویسنده مسئول)
محمد جعفری، استاد دانشکده منابع طبیعی دانشگاه تهران
ارغوان شهلایی، دانشجوی کارشناسی ارشد، دانشگاه آزاد اسلامی واحد علوم و تحقیقات
سارا جمالپور، دانشجوی کارشناسی ارشد، دانشگاه آزاد اسلامی واحد علوم و تحقیقات

چکیده

هدف از این تحقیق مکان یابی عملیات اصلاح و احیاء مراتع است. مطالعه حاضر در حوزه آبخیز حسین آباد به مساحت ۷۱۶۲ هکتار واقع در جنوب غربی شهرستان فارسان از استان چهارمحال بختیاری در کشور ایران انجام شد. حوزه دارای کاربری‌هایی مختلفی شامل: مرتع، جنگل، زراعت آبی و باغ، زراعت دیم، مسکونی و توده سنگی است. در تحقیق حاضر طی فرآیند آمایش سرزمین ابتدا توان اکولوژیکی مراتع و جنگل‌های این حوزه آبخیز به دست آمد. پس از انجام توان‌سنجی با در نظر داشتن حفظ کاربری‌های موجود و جلوگیری از تخریب بیشتر مناطق، برنامه‌های اصلاحی ارائه شد. در این راستا لایه‌های اطلاعاتی مورد نیاز شامل: طبقات ارتفاعی، طبقات شیب، طبقات جهات شیب، وضعیت پوشش و گرایش مرتع، اقلیم، گروه هیدرولوژی خاک، عمق، بافت خاک، زمین شناسی و ژئومورفولوژی در محیط نرم افزاریArcGIS 9.3 روی هم اندازی شد و تعداد ۲۸۰ واحد همگن به دست آمد. نتایج به دست آمده از بررسی ویژگی‌های هر یک از واحدهای همگن نشان‌دهنده این است که منطقه دارای طبقه یک حفاظتی، توان سه مرتعی و توان شش جنگلی و همچنین توان سه و چهار کشاورزی و کشاورزی غیر مجاز است. در نهایت با توجه به ویژگی‌های توان‌های به دست آمده و تعریف معیارهای لازم برای پیشنهاد هر برنامه اجرایی، محل و نوع برنامه‌های اصلاحی قابل اجرا نظیر قرق، کپه‌کاری، تبدیل دیمزارهای کم‌بازده به کشت نباتات علوفه‌ای و احیاء کمی و کیفی جنگل پیشنهاد شده است.

کلمات کلیدی: روش‌های مصنوعی، اصلاح، جنگل و مرتع، احیاء، سیستم اطلاعات جغرافیایی (GIS)