Systemic Management of Mountainous Rangeland Ecosystem, Case Study: The Javaherdeh Rangeland of Ramsar

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Abstract. Mountainous rangeland ecosystems have a highly delicate position in ecologic area because of severe environmental conditions and having wildlife and livestock. Knowing and realizing the biotic and abiotic components, which have an interaction with each other in this ecosystem, perform the most important role in to desirable management of it. The systematic management is one of the managing features such as modern approach for land management and suitable use of upland ecosystems. To reach that, mountainous rangelands of Javaherdeh (Ramsar) via 1:25,000 scale map were selected. Density, rangeland conditions, vegetation cover, gravel and grit were determined by Superficial and modified six-factor methods, Arc GIS v.9.3 software was employed to achieve land form map which was obtained by the combination of altitude, slope, and slope aspect maps. First, basic and first environmental unit maps were changed with land form map into soil type map, and first basic map into vegetation type map. The proposal map of systematic management of area was associated with final environmental unit map into landuse map via their attribute table. The established proposal map shows accurate position of different future land uses on the basis of current ecological capabilities of areas. Around Javaherdeh village is suitable for extensive outdoor recreation (7.59%) and appropriate for the grazing of livestock (62.22%). Some areas (20.07%) also should be protected because of landslides and debris formation.

Keywords: Systematic management, Rangeland ecosystem, Mountainous rangeland, Javaherdeh, Ramsar.

Introduction

Upland rangelands have immature soils, shaky geologic structures, expressed hydrologic cycle (Khaledi, 2006), and different debris which are occupied by alpine and semi alpine vegetation cover, including spiny bushy species and short grasses with short vegetative period that are grazed by livestock and wildlife herbivora. Moreover, different attractive outlooks of these areas gather up many climbers and ecotourism (Rezvani, 2001) who impact double encumbrance on these sensitive ecosystems (Smyth & Dumanski, 1995; Young *et al*., 2005). Hence, mountainous rangeland ecosystems have a highly delicate position (Irani Behbehani & Shafiei, 2007) in ecologic area. Dope and realising of biotic and abiotic components which have an interaction with each other in this ecosystem performs the important role in desirable management of it. The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system (Costanza *et al*., 1997). As it has been known there is one land to live, produce, grow, and die. The FAO (1995) defined Land as a delineable area of the earth's terrestrial surface encompassing all attributes of the biosphere immediately above or below this surface including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes and swamps), near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.). Land also performs a multitude of vital and key environmental, economic, social and cultural functions, for life (FAO, 2007).

It, from now, needs to be evaluated continuously through ecological capabilities. Land evaluation assesses the suitability of land for specified land uses (Beek *et al*., 1997). Land evaluation also is the process of predicting the potential use of land on the basis of its attributes (Rossiter, 1996). A variety of analytical models can be used in these predictions, ranging from qualitative to quantitative, functional to mechanistic and specific to general. There is a large literature on land evaluation as Rossiter (1996) has reported articulated methods till he has done his research. Initially land evaluations were carried out mostly for land use planning and land development projects (FAO, 2007) which include the agricultural land capability classification (U.S. Department of the Interior Bureau of Reclamation, 1951; Klingebiel & Montgomery, 1961), Framework for Land Evaluation (FAO, 1976), the LECS system in Indonesia (Wood & Dent, 1983), land evaluation in dryland agriculture (FAO, 1983), the Booker Tropical Soils Manual (Landon, 1984), forestry (FAO, 1984), climate usage to evaluate the rangeland land use (Zolvend, 1985), irrigated agriculture (FAO, 1985), steeplands (Siderius, 1986), Agricultural Compendium (EUROCONSULT, 1989), extensive grazing (FAO, 1991), expert-systems approach which is the ALES framework (Rossiter, 1990; Rossiter & Van Wambeke, 1995), and land evaluations in Mediterranean climates by MicroLEIS (De la Rosa *et al*.,1992) for land evaluations in Mediterranean climates, and many computer models of land processes have been used to evaluate single land qualities, e.g. the pesticide leaching model, LEACHM (Hutson & Wagenet, 1991; 1992).

Nowadays, the focus of land evaluation is mainly placed on solving technical as well as socio-economic and environmental problems in the use of lands which are fully utilized already and often are overexploited and degraded. At the present time, land evaluations help solving the conflicting demands on limited land resources (FAO, 2007). These methods concern the different position of land including GIS-MCA integration (Janssen and Rietveld, 1990; Mohajeri, 1991; Carver 1991; Eastman *et al*., 1993; Pereira and Duckstein, 1993; Jankowski and Richard, 1994; Jankowski, 1995; Prato, 1999), SysNet (system network) to obtain an approach to evaluate the strategic limitations and opportunities of natural resources (van Ittersum *et al*., 2004; Amiri, 2009; Movahed, 2010), Ecological Footprint (Wackernagel & Rees, 1997; Saraie, 2009), GIS-based Analytical Hierarchy Process (Makowski, 2004), the ecological capability of different landuse of the land (van Gool *et al*., 2005), Sensitivity analysis (AHP-SA) tool to improve the reliability of Multi-Criteria Decision-Making (MCDM) which is used to evaluate cropland suitability (Roudgarmi *et al*., 2007; Wallenius *et al*., 2008; Chen *et al*., 2009).

Over the past decade, great strides have been made in developing and refining methods of assessment for identifying priorities for conservation plans (Margules and Pressey, 2000; Groves, 2003). In Iran, however, the study on systematic analysis of different land uses has been started by Makhdoum (1988) who has introduced the Land Use Planning method as an approach of land management (Hurni, 2000; Auzins, 2004). The land use planning results from a reasonable compromise between the environmental potential measured in terms of the availability of natural resources (Makhdoum, 1993; Makhoum *et al*., 2011) and the social demand measured in terms of the requirements of goods and services by specific human communities (Bocco *et al*., 2001). The evaluation of ecological capability considers the potential capability of land by means of executable and foreseeable land-uses (Ale Sheyk, 2009). Since this method contains different aspects of land use, it is multi-factor method by which evaluating will be done more accurate (Adhami Mojarad, 1989, 1994). This method and the others are attempted to evaluate the land use as sustainable. A sustainable use and development of landscapes are to integrate aspects of environmental protection, social welfare and economic growth and meet further demands such as providing sites for development, raw material processing or waste disposal evaluation (Wiggering *et al*., 2006). In order to obtain sustainable circumstance of land, systematic analysis of land, therefore, is considered to assess the upland rangeland of northern aspect of Alborz in Javaherdeh (Ramsar).

Material and Methods

Study area is the upland rangeland in the Javaherdeh village (Fig. 1) which is cold and humid with altitude and longitude from 1600-2800m and 2800-3600m, respectively. The soil texture is sandy-loamy, clay-loamy, and silt-clay-loamy in different positions of area. Plant formations in first altitude class are formed by grasses and forbs with some spot busy trees as it changes to cushiony-spiny species including astragali and holy clover in the second elevation step, especially in steep slopes and debris features (Jouri, 2010).

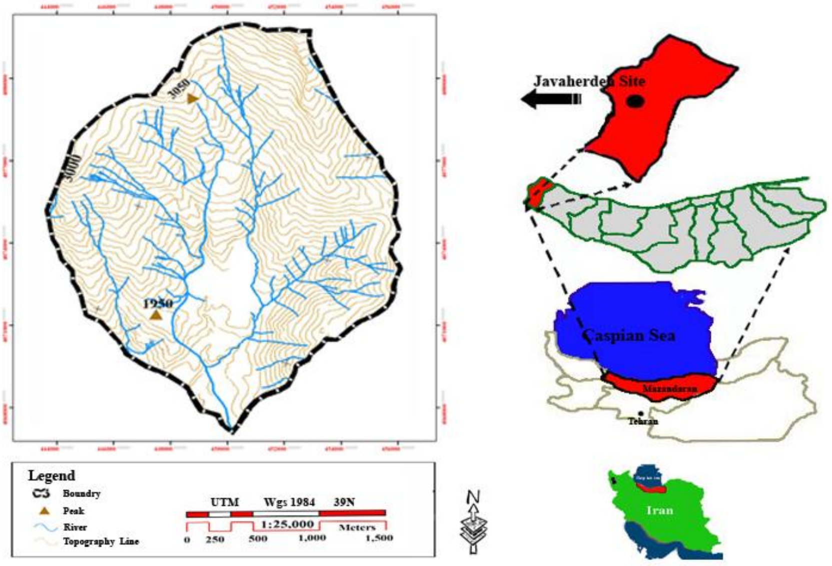

Fig. 1. Position of study area in Mazandaran province

Research Methods

On the first occasion, basic maps have been provided including topographic map (1:25,000), and Geologic and pedologic maps (1:100,000). The study area's milieu was determined by topographic map and field monitoring which was 500 ha range. In order to survey the vegetation traits, plant cover density and rangeland conditions, random sampling was selected. Sample size and volume were obtained by Statistical (Mesdaghi, 2004) and Minimal Area (Cain, 1932; Cain & Castro, 1959) methods, respectively. Plant volume density, rangeland conditions and vegetation cover percentage are respectively acquired by Superficial (Bonham, 1989) and Six-factor (Daubenmire, 1959), Methods modified by Bassiri (2000).

In the second place, systematic analysis of land was executed by below steps (Makhdoum, 2011):

1) Combination of altitude, slope, and aspect maps to obtain the landform map (steps 1,2,3, Table 1)
2) Compilation of landform map into soil type map (step 4, Table 1) to achieve the first environmental unit map.
3) Incorporation of the first environmental unit map into vegetation type and density map (step 5 and 6, Table 1) to come by the second environmental unit map.
4) Compiling the first environmental unit map to current land use map (step 7, Table 1) to catch up with final environmental unit map.
5) Extraction of attribute tables of environmental units.
6) Representation of proposal map for systematic management of the study area.

Inasmuch ecological data are almost used as map for the evaluation and programming of the land, it needs to abstract some attributes of maps in a table which is not possible to exhibit them in map legend (Makhdoum, 2011). On the other hand, the attributes of basic maps including elevation, slope and aspect are given in Table 1 because of their occupancy in more pages. Classes of each unit in maps are derived on the basis of land properties in the study area as well as Makhdoum (2011) has pointed out it.

Table 1. Attributes of basic maps to obtain the applied maps

Steps	1	2	3	4	5	6	7
Class	Elevation Class (m)	Slope Class (%)	Slope Aspect Class	Soil type	Vegetation type	Vegetation Density (%)	Landuse (Lu)
1	1450-1650	0-10	Flat	Clay	*Ph. Pe.-Tr. Re.*	75	Dry Farming (DF)
2	1650-1850	10-20	North	Clay- loamy	Br.To-Tr.Re.-Hy.Ra	85	High Density Forest (F1)
3	1850-2050	20-30	Northeast	Loam	On.Co.-Fe.Ov.	94	Medium Density Forest (F2)
4	2050-2250	30-40	East	Silt-clay-loam	Ca.St.-On.Co.-Br.To	95	Mixed Forest/Orchard (FO)
5	2250-2450	40-50	Southeast	Silt	-	99	Agricultural Area with Limitation (I2)
6	2450-2650	50-60	South	Silt-loamy	-	100	Orchard (O)
7	2650-2850	>60	Southwest	-	-	-	High Density Rangeland (R1)
8	2850-3050	-	Northwest	-	-	-	Medium Density Rangeland (R2)
9	3050-3250	-	-	-	-	-	Urban Area (U)
10	3250-3450	-	-	-	-	-	-

All mentioned processes have been performed using ArcGIS for Desktop v.9.3 software (ESRI Inc., 2010).

Results and Discussion

Description of current position of study area

On the basis of field monitoring, it has been distinguished four vegetation types in the study area which their characteristics are given in Table 2. As the truth, current rangeland conditions (R.C) in two types are poor whereas in the other types, they are seen as fair and good conditions. A notable point in this table is that two poor-condition types have an acceptable rate of plant cover percentage. because the type of *Phlomis persicus- Trifolium repens* is settled around the Javaherdeh village which is grazed by herd of sheep and goats and free grazers including horses and cows. From the other point of view, the type of *Carex stenophylla- Onobrychis cornata-Bromus tomentesus* is mostly predominated on debris formation with massive outcrop cliffs and steep slopes. Not only it has the second area in the study region, but it also has the second less animal unit (AU). Therefore, severe environmental circumstances of this type put it in the poor condition class. Although the type of *Bromus tomentesus-Trifolium repense- Hypochopris radicata* has occupied the most area (2074.43 ha), it also has the most animal unit per 100 days. It, however, has fair conditions with constant tendency. The last type, which has conquered in the high altitude and slope, has good conditions with progressive trend as well as the uttermost soil conservation.

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Table 2. Traits of vegetation types in study area

Vegetation Type	Area (ha)	Slope (%)	Slope aspect	Plant cover (%)	Soil conservation (%)	R.C score	R.C class	R.C. trend	AU. per 100 days
Phlomis persicus-Trifolium repens	651.1	0-60	All aspect	84.2	37.1	31.9	Poor	Regressive	978
Bromus tomentesus-Trifolium repense-Hypochopris radicata	2074.43	20-85	All aspect	99	68.71	54.66	Fair	Constant	6219
Onobrychis cornata-Festcua ovina	1207	15-88	All aspect	100	80.25	70.2	Good	Progressive	4764
Carex stenophylla-Onobrychis cornata-Bromus tomentesus	1019.29	40-90	All aspect	90	57.3	45.54	Poor	Constant	1445

Producing and Processing of Compiled Maps

In order to prevail the accumulated maps in the study area, different ecological models of land-use are used based upon the current ecological capabilities, including forestry (Fo), rangeland (Ra) and agriculture (Ag), aquaculture (Aq), environment protection (Ep), extensive (Et) and intensive (It) tourism (Fig. 2) and rural development (Ru) that ecological capability of forestry and intensive tourism of land-uses were not qualified for the proposal map. It has not merited agriculture land-use for this area (model 1). Whereof some spots of a given area (unit) are used for various landuse, it is better to select the best choice of land-use as expected land-use for that unit. In this case, it follows two aims including considering the human's requirements and protection of environment (Langdalen, 1975; Way, 1978; Smith, 1982; Westman, 1985; Ive and Cocks, 1986; Bocco *et al.*, 2001; Makhdoum, 1992, 2011). The current landuse of the study area shows that the most areas are used for grazing as rangeland habitat.

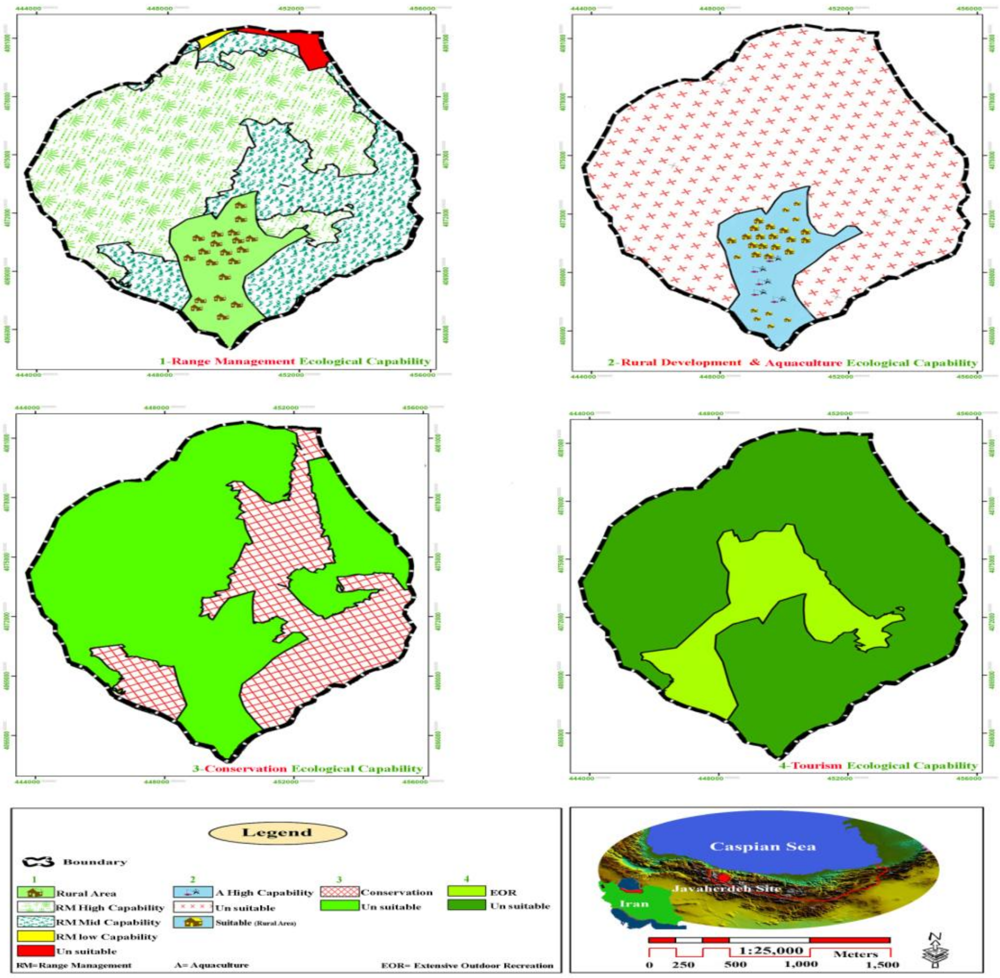


Fig. 2. Current ecological capabilities of utilities in Javaherdeh site

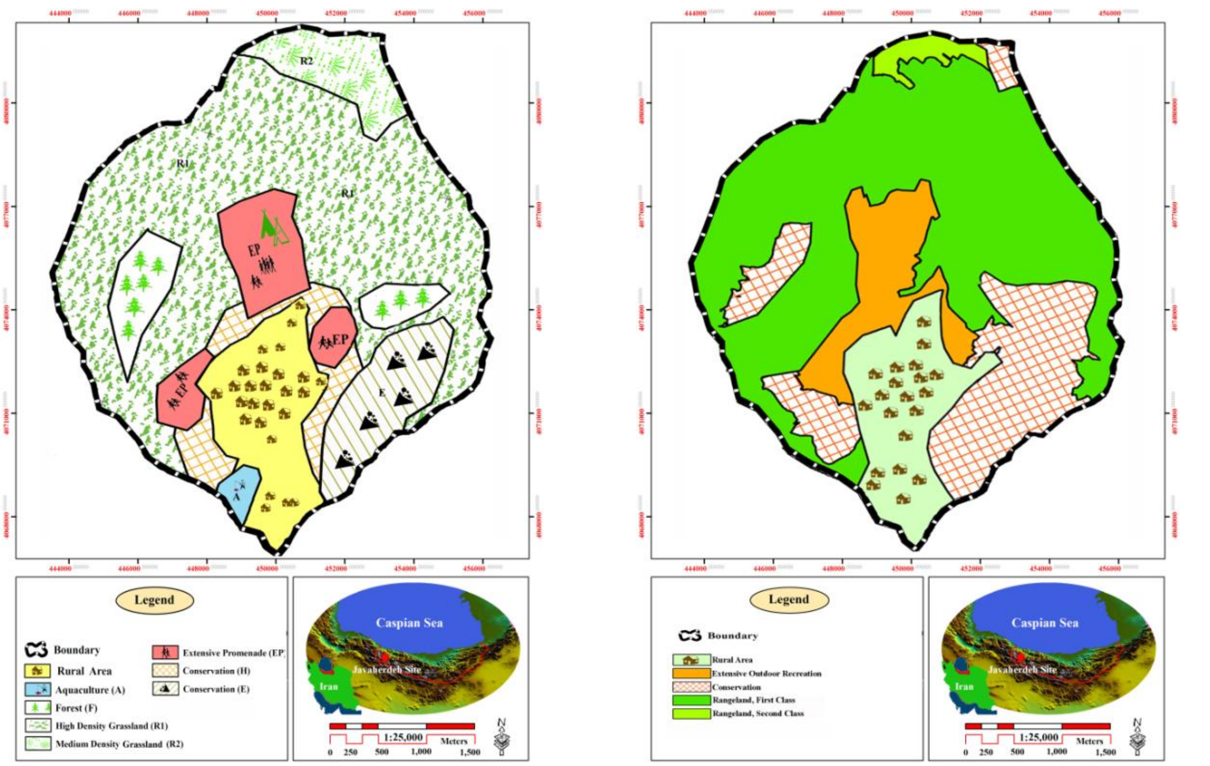
Providing a Proposal Map

The final map of environmental unit and its attribute tables are suitable for decision making of the ecological capability of all kinds' land-uses. As a matter of fact, there is current land use (Table 1, step 7; Fig. 3a) in this area which combination of it into the current ecological capabilities of land utilities (Model 1) extracts a final map as the proposal preference of land-use (PPLU) or management plan of land map (Fig. 3b). It should be stated that geologic, erosion, and land unit maps are also used basically to better decision-making of ecological ability in each ground unit (Makhdoum, 2006).

Model (1):

$$PPLU = Ra(4,5,6,7) + Aq(1,2) + Ep(1,2) + Et(2,3) + Ru(2,3) + Lu(1,2,3,4,5,6,7,8,9) - Fo(7) - It(3) - Ag(7)$$

In this model(Model 1), numbers in parenthesis hold out the classes of each land-use on the basis of current ecological capabilities of the land. Symbol of (+) shows the compiling of maps and symbol of (-) also shows the extracted land-uses from final map because of unsuitable features in this area. The aquaculture land-use is also jointed into rural area because fish husbandry pools are located in this area. In fact, some parameters in each class based upon the land capacity in this area are modified on the basis of Makhdoum (2011) advice.



(a) Current Landuse Map **(b) Proposal Preference of Land-Use Map**

Fig. 3. Management plan of land map of Javaherdeh rangelands

If it is accepted that management programs of land utilities formed upon the current ecological capability in the study area, then future of land merits will mostly be rangeland first class (Table 3). On one hand, because of debris formation around the village, second-dominated area (20.07%) should be protected from any activities. Unfortunately, destroying this area by human activities has a high rate. If this procedure continues, then more parts of the area might be conserved. On the other hand, because of wild animal, like birds, snakes, lizards, wild four-footed animal some highland with steep slopes, debris and landslide formation could also be sheltered.

Table 3. Area and percentage of each land-use of land in study area

Future land-use	Area (ha)	Percentage
rangeland second class	123.73	2.49
protected area	993.87	20.07
rural area	501	10.12
extensive outdoor recreation	375.76	7.59
rangeland first class	2957.46	59.73
Sum	4951.82	100

Some areas are pronounced as second class rangeland area (2.49%). Actually, this region is grazed by wildlife mammal such as wild goat, gazelle and wild ewe. It can also be used by domestic goats that one pure goat herd grazes in this area by grazing permission. The Javaherdeh village is settled between end-forest line and outset of rangeland with winsome weather that gather up many people in mid spring to end summer. Although house building is unluckily growing every year, from the other point of view, these people need the outdoor recreation region which has also been antedated by PPLU map so that their percentages seem nearby each other.

Conclusion

The evaluation of ecological capability is the landuse managing that can be provided by information layers (databases) as maps. Production of applied maps is turned out the land unit in which a micro ecosystem is determined (Makhdoum, 1992) as a management unit. Hence, the view of land, which is given by GIS output, is comprised all features of the ecological capability of a land unit. Management goals can be achieved by the systematic view of land (Hurni, 2000; Auzins, 2004). In this system, ecosystem ability is anticipated by coincidences of one by one's capacity of sustainable-ecologic resources in which each obtained ecosystem has unity and homogeneity in the ecological resources (Makhdoum, 2006; Ale Sheyk, 2009). Recognition of the land, introduction of its capacity and using of it in ecologic-sustainable utilization process, are a firm and hard work that systematic evaluation of land can draw it as well as.

The Javaherdeh rangelands as fragile ecosystem (Irani Behbehani & Shafiei, 2007) accept many people, e.g. human and livestock, who bring hindrance with own themselves to these area. It has been presented (Fig. 3) that this area mostly should be used as grazingland. Moreover, field monitoring analysis also emphasizes on it (Table 2). Because of desirable and fresh weather in this area, many people come here every summer and they make double pressure on sensitive rangeland ecosystem. On this opportunity, systematic management of land draws a managing plan to conduct of the land on the basis of its capacity (Adhami Mojarad, 1989, 1994). This ability has been precisely derived from the research results to ecologic-stable management of the study area. It may be recommended to use and modify this method for sustainable use of rangelands in the other regions of Iran.

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Reference

Adhami Mojarad, M. H., 1989. Comparison of three evaluation methods of natural resources, Ms. Thesis, Tehran University, 120p. (In Persain).

Adhami Mojarad, M. H., 1994. Determination of rangeland utilization using landuse planning method, 175-182, first national conference of range and range management, Industry University of Isfehan, 5-7 July, 488p. (In Persain).

Ale Shek, A., S.A. Jouzi & S. Rezaian, 2010. Planning the model to evaluate of ecological capability of land in order to establish the urban and services development utilization. *Jour. Environmental Science and technology*, **43(4):** 127-139.

Amiri, M.J., 2009. The evaluation of ecologic capability of forests in Dohezar and Sehezar catchments of north Alborz using GIS. *Jour. Environmental Studies*, **35(50):** 33-44. (In Persain).

Auzins, A., 2004. Institutional Arrangements: A Gate Towards Sustainable Land Use. Nordic *Jour. Surveying and Real Estate Research*, **1:** 57-71.

Bassiri, M., 2000. Analysis and inventory of Rangeland, lecture manuscript, Industrial University of Isfehan, Iran.

Beek, K.J., K., De Bie, & P.Driessen, 1997. Land information and land evaluation for land use planning and sustainable land management. The Land, **1(1):** 27-44.

Bocco, G., M. Mendoza & A. Velazquez, 2001. Remote sensing and GIS-based regional geomorphological mapping—a tool for land uses planning in developing countries. Geomorphology, **39:** 211–219.

Bonham, C. D., 1989. Measurements for terrestrial vegetation. John Wiley and Son, New York, NY.

Cain, S. A. O. De & G. M. Castro, 1959. Manual of vegetation analysis. Harper and Bros. Publishers, New York. 325 pp.

Cain, S.A., 1932. Concerning certain ecological concepts. Ecological Monoger, **27(2):** 475-508.

Carver, S., 1991. Integrating multicriteria evaluation with GIS, *International Jour. Geographical Information Systems*, **5(3):** 321-339.

Chen, Y., J. Yu, K. Shahbaz & E. Xevi, 2009. A GIS-Based Sensitivity Analysis of Multi-Criteria Weights. 18th World IMACS/MODSIM Congress, Cairns, Australia, 3137- 3143.

Costanza, R., R. d'Arge, R. de Groot, S. Farberk, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R.G. Raskin, P. Suttonkk & M. van den Belt, 1997. The value of the world's ecosystem services and natural capital. Nature, **387(15):** 253-260.

Daubenmire, R., 1959. A Canopy-coverage method of vegetational analysis. Northwest Science, **33:** 43-64.

De la Rosa, D., J.A. Moreno, L.V. Garcia & J. Almorz, 1992. MicroLEIS: A microcomputer-based Mediterranean land evaluation information system. Soil Use & Management, **8:** 89-96.

Dent, D. & Young, A. 1981. Soil survey and land evaluation. George Allen & Unwin, London, England.

Eastman, R.J., P.A.K. Kyen, & J. Toledno, 1993. A procedure for multiple-objective decision making in GIS under conditions of conflicting objectives. In: J. Hents, H.F.L. Ottens, and H.J. Scholten (eds.), Proceedings Fourth European Conference on GIS, **1(2):** 438-447.

ESRI (Environmental Systems Research Institute) Inc., 2010. ArcGIS for Desktop v.9.3 software, http://www.esri.com.

EUROCONSULT. 1989. Agricultural Compendium for rural development in the tropics and subtropics. Elsevier, Amsterdam.

FAO. 1976. A framework for land evaluation. Soils Bulletin 32. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO 1983. Guidelines: land evaluation for rainfed agriculture. Soils Bulletin 52. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO 1984. Land evaluation for forestry. Forestry paper 48. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO 1985. Guidelines: land evaluation for irrigated agriculture. Soils Bulletin 55.

Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO 1991. Guidelines: land evaluation for extensive grazing. Soils Bulletin 58. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, 1995, planning for sustainable use of land resources; towards a new approach. FAO Land and Water Bulletin 2. Rome, Italy.

FAO, 2007. Land evaluation, towards a revised framework. Food and Agriculture Organization of the United Nations. Rome, Italy, 124P.

Groves, C., 2003. Drafting a Conservation Blueprint. A Practitioner's Guide to Planning for Biodiversity. Island Press, Washington, DC.

Hurni, H., 2000. Assessing sustainable land management (SLM). Agriculture, Ecosystems and Environment, **81:** 83-92.

Hutson, J.L. & R.J. Wagenet, 1991. Simulating nitrogen dynamics in soils using a deterministic model. Soil Use & Management **7:** 74-78.

Hutson, J.L. & R.J. Wagenet, 1992. LEACHM: Leaching Estimation and Chemistry and Model. A process-based model of water and solute movement, transformation, plant uptake and chemical reactions in the unsaturated zone. Version 3. SCAS

Irani Behbehani, H. & B. Shafiei, 2007. Landscaping of mountain using endemic plants, *Jour. Environmental Studies*, **33(42):** 109-124. (In Persain).

Ive, J. R. & K.D. Cocks, 1986. Rural land use planning techniques. In " Micro Computer For Local Government planning and management. Ed (P. W. Newton and M.A.P. Tyalor) Hargreen pub. Co. Sydney:112-122

Jankowski, P., 1995. Integrating geographical information systems and multiple criteria decision-making methods, *International Jour. Geographical Information Systems*, **9(3):** 251-273.

Jankowski, P., & L. Richard, 1994. Integration of GIS-based suitability analysis and multicriteria evaluation in a spatial decision support system for route selection, Environment and Planning B, **21:** 323-340

Janssen, R., & P. Rietveld, 1990. Multicriteria analysis and geographical information systems: An application to agriculture land-use in Netherlands. In: H.J. Scholten, and J.C.H. Stillwell (eds.) Geographical information systems for urban and regional planning, pp. 129-139. Dorchecht: Kluwer Academic Publishers

Jouri, M. H., 2010. Ecological investigation of upland rangeland in two geographical scale of Irano-Touranian and Euro-Siberian. PhD thesis, Pune Unversity, India, 690p. (In Persain).

Khaledi, Sh., 2006. Studying of microclimate in mountainous area, case study: Damavand region, *Jour. Environmental Studies*, **41:** 45-54. (In Persain).

Klingebiel, A.A. & P.H. Montgomery, 1961. Land capability classification. USDA Agricultural Handbook 210. US Government Printing Office, Washington, DC.

Landon, J.R. (ed.) 1984. Booker tropical soil manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Longman, New York.

Langdalen, E., 1975. Conservation of the natural and cultural landscape as an integral part of the municipal survey plan. Proc. Symp. Ecology and planning. Stockholm. National Swedish environment. Protection board: 89-97.

Makhdoum, M.F., 1988. Introduction an modern model to land evaluation in landuse planning process, *Iranian Jour. Natural Resources*, **41(1):** 68-78. (In Persain).

Makhdoum, M. F. 1993. Environmental Unit: An arbitrary ecosystem for land evaluation. (In Persain).

Makhdoum, M.F., 2006. Fundamental of landuse of planning. University of Tehran press. Pp 289. (In Persain).

Makhdoum, M.F., A.A. Darvishsefat, H. Jafarzadeh & A.F. Makhdoum, 2011. Environmetal evalatuion and planning by Geographic information system, 5th edition, University of Tehran press, Tehran, Iran, 306p. (In Persain).

Makowski, M., 2004. Multi-objective Decision Support Including Sensitivity Analysis. UNESCO-EOLSS Joint Committee, Encyclopedia of Life Support Systems, Paris, Eolss Publishers, p. 24, http://www.eolss.net, article no 001-373 (4.20.4.3)

Margules, C.R. & R.L. Pressey, 2000. Systematic conservation planning. Nature, **405:** 243-253.

Mesdaghi, M., 2004. Range Management in Iran, Astane ghods publication, Mashhad, Iran, 333p. (In Persain).

Mohajeri, A.R., 2001. An investigation of surface, capacity, condition, and trend of rangeland using GIS technic. 332-344, first national conference of range and range management, Industry University of Isfehan, 5-7 July, 488p. (In Persain).

Movahed, A., 2010. The evaluation of ecological capability of Dez territory, from regulator dam to Ghir dam for recreation. *Jour. Environmental Studies*, **36(55):** 13-24. (In Persain).

Pereira, J.M.C., & L. Duckstein, 1993. A multiple criteria decision-making approach to GIS-based land suitability evaluation, *International Jour. Geographical Information Systems*, **7(5):** 407-424.

Prato, T., 1999. Multiple attribute decision analysis for ecosystem management. Ecological Economics, **30:** 207- 222.

Rezvani, A.A., 2001. The role of ecotourism in protection of environment. *Jour. Environmental Studies*, **31:** 115-122. (In Persain).

Rossiter, D.G. 1990. ALES: A framework for land evaluation using a microcomputer. Soil Use & Management, **6:** 7-20.

Rossiter, D.G. & Van Wambeke, A.R. 1995. Automated Land Evaluation System: ALES Version 4.5 User's Manual. December 1994 printing. SCAS Teaching Series No. T93-2, Revision 5. Cornell University, Department of Soil, Crop & Atmospheric Sciences, Ithaca, NY.

Rossiter, D.G., 1996. A theoretical framework for land evaluation. Reprint of Geoderma, **72:** 165-202.

Roudgarmi, P., N. A. Khorasani, S.M. Monavari & J. Nouri, 2007. Environmental impact assessment of developmen using Multi-Criteria Evaluation Functions, *Jour. Environmental Science and Technology*, **9(4):** 73-84. (In Persain).

Saraei, M., 2009. The Ecological Footprint as an indicator to evaluate the social sustainment. *Jour. Environmental Studies*, **35(50):** 15-26. (In Persain).

Siderius, W. (ed.), 1986. Land evaluation for land-use planning and conservation in sloping areas. ILRI Publication 40 International Institute for Land Reclamation and Improvement (ILRI), Wageningen.

Smith, R. S., 1982. The use of land classification in resource assessment and rural planning. Inst. Ter. Ecology. Nat. Environ. Res. Council. Cambridge.

Smyth, A.J., & J. Dumanski. 1995. A framework for evaluating sustainable land management. Can. J. Soil Sci. **75:** 401–406.

U.S. Department of the Interior Bureau of Reclamation 1951. Irrigated land use, Part 2: Land classification. Bureau of Reclamation Manual. Vol. 5, U.S. Government Printing Office, Washington.

van Gool, D., P. Tille & G. Moore, 2005. Land evaluation standards for land resource mapping, third edition. Resource Management Technical Report 298. 141p.

van Ittersuma, M.K., R.P. Roetter, H. van Keulen, N. de Ridder, C.T. Hoanh, A.G. Laborte, P.K. Aggarwal, A.B. Ismail & A Tawang, 2004. A systems network (SysNet) approach for interactively evaluating strategic land use options at sub-national scale in South and South-east Asia. Land Use Policy, **21(2):** 101-113.

Wackernagel, M. & W. Rees, 1997. Perceptual and structural barriers to investing in natural capital: economics from an ecological footprint perspective. Ecol. Econ., **20(1):** 3-24.

Wallenius, J., J.S. Dyer, P.C. Fishburn, R.E. Steuer, S. Zionts, and K. Deb, 2008. "Multiple Criteria Decision Making, Multiattribute Utility Theory: Recent Accomplishments and What Lies Ahead", presented at Management Science, 1336-1349.

Way, D. S. 1978. Terrain Analysis. 2nd ed. Dowden Hutchinson and Ross, Inc. Stroudsburg. 438pp.

Westman, W. E. 1985. Ecology, Impact assessment, and environmental planning. J. Wiley and sons. Newyork. 532pp.

Wiggering, H., C. Dalchow, M. Glemnitz, K. Helming, K. Muller, A. Schultz, U. Stachow & P. Zander, 2006. Indicators for multifunctional land use-Linking socio-economic requirements with landscape potentials. Ecological Indicators, **6:** 238–249.

Wood, S.R. & Dent, F.J. 1983. LECS: a land evaluation computer system. AGOF/INS/78/006. Vol. 5 (Methodology) & 6 (User's Manual), Ministry of Agriculture, Government of Indonesia, Bogor, Indonesia

Young, J., A. Watt, P. Nowicki, D. Alard, J. Clitherow, K. Henle, R. Johnson, E. Laczko, D. McCracken, S. Matouch, J. Niemela & C. Richard, 2005. Towards sustainable land use: identifying and managing the conflicts between human activities and biodiversity conservation in Europe. Biodiversity and Conservation, **14:** 1641–1661

Zonveld, D., 1983. Principle of land evaluation for extensive grazing, proceeding of workshop on land evaluation, Addis ababa, Ethiopia, 84-117.