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Allocating rangelands to the optimum land use by applying a Decision Support System

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Introduction

Rangelands in Iran are faced with a considerable level of degradation and human interventions due to pressures for increased food production and the need to generate more benefits for an increasing population. A first step in solving this problem is to develop methodology to efficiently analyse the current situation and effectively reallocate rangelands into optimum land uses. To achieve an agreed solution for land allocation, an interactive approach is required to recognize and comprehensively assess different alternatives.

This paper suggests an introductory framework for developing a decision support system for allocation of rangeland areas into the most optimum use.

Methods

In the first stage of this framework development, possible scenarios for land use zoning will be produced using a Linear Programming Model based on the objective functions defined on the basis of different stakeholders' attitudes and preferences. For this purpose, it is necessary to specify Land Mapping Units (LMUs) and also alternative utilizations such as Land Utilization Types (LUTs) based on the land potential in every region. These LUTs will be defined as to be biophysically and technically feasible, environmentally suitable, socially acceptable, economically viable and legally supported.

After quantification of inputs and outputs of land use system (LMUs, LUTs) in the form of matrices, different scenarios are produced using land use planning softwares and the best and most appropriate scenario is selected based on desired criteria and their priority. For this purpose, the Effects Matrix is generated by calculating or estimating the effect of each scenario on each criterion. There are different methods for the evaluation and ranking of scenarios, such as compensatory approach and weighted summation, outranking and non-compensatory approach.

The data should be standardized using the common methods like maximum standardization, interval standardization, goal method, and then, logical weights are attributed to the criteria using prevalent methods like direct weighting, pair-wise comparison and random method.

A case study in Central Alborz rangelands

Central Alborz rangelands are a mountainous ecosystem located in the semi-steppe zone which has undergone many disruptions during recent years due to the rapid development process. This 38900-acre area is located 120 km northwest of Tehran with an average annual rainfall of about 630 mm. The area is including 17 vegetation types mostly covered by *Astragalus* species and various perennial grasses such as *Agropyron tauri*, *Bromus tomentellus* and *Stipa barbata*. Despite the relatively favorable climatic conditions for the growth of desirable plant species, human interference excessive rural livestock grazing (including sheep and goats) has caused the composition and density of desirable species to decline and in contrast, inferior plants are more developed. Within the proposed framework to find the best combination of land uses in Central Alborz rangelands, various scenarios were produced on the basis of different stakeholders' objectives and then, these scenarios were ranked based on socio-economic and ecological criteria.

In this case study, four Land Utilization Types were defined according to environmental conditions and recognized potentials of rangelands, including limited forage harvesting for livestock (LUT1), structured tourism (LUT2), beekeeping (LUT3) and structured conservation of rangelands (LUT4). Also 17 homogenous Land Mapping Units were identified by overlaying environmental data layers.

In order to generate different scenarios, criteria values affected by implementation of each LUT on each LMU were calculated and matrices related to costs; gross direct benefits; number of livestock; the economic value of soil conservation, water retention and gas regulation functions and job creation were formed as the effective factors in decision-making process. Linear programming technique was applied for generating different scenarios according to objective functions of different stakeholders, including net direct benefits maximization, minimization of livestock number, job creation maximization, maximization of the economic value of water retention function, maximization of the economic value of soil conservation function, maximization of total economic value of water and soil conservation functions, maximization of the economic

value of gas regulation function and maximization of total economic value of (water, soil and gas) regulation functions. Scenario assessment and ranking was performed using Definite software (Institute for Environmental Studies, 2000). Desired criteria for scenario assessment included economic criteria (gross direct benefits, the costs of direct benefits, carrying capacity), social criteria (job creation, diversity of proposed land utilizations as a measure of risk) and environmental criteria (economic value of water retention function; economic value of soil, water and gas regulation; area of the current situation). In this step, the effect of each scenario on each criterion was calculated and these values were standardized using the Goal method (Farahpour, 2002). Then the criteria were weighted by pair-wise method and scenarios were ranked using weighted summation method. Results indicated that SC3 scenario is located in the first rank and other scenarios with a small distance in the next orders. The current situation is placed far from other scenarios in the final order. Best case scenario (SC3) was designed with the objective function of maximum employment in the region in a manner that the restrictions on land and livestock are also considered. The purpose of land area restriction is that the total area of land allocated to LUTs should not exceed the area of each LMU. Also the purpose of livestock number restriction is that land use planning should be scheduled in a way that the number of animals would not be lower than the current situation, given that animal husbandry is the main source of livelihood in the area.

Finally, sensitivity analysis was performed to assess the strength of ranking and its sensitivity to uncertainties in the criteria, their values and weights assigned to them, using Monte Carlo method. Results reflect the strength of the ranking.

Conclusion

Discussions and the mentioned case study indicate that the use of planning support systems help to make decisions about the sensitive issue of land use planning and zoning. By using these systems and considering different stakeholders' attitudes and several socio-economic and ecological criteria, the conflicts between operators and planners will be minimized which would help to programs sustainability. Obviously according to the existing software capabilities, these systems are highly flexible for updating the criteria and assigned weights to them on the basis of spatial and temporal circumstances. Other researchers such as Campbell *et al.* (1992), Jankowski *et al.* (1997), Teclé *et al.* (1998) and Farahpour (2002) also confirmed the ability of these systems in land use planning and management.

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