Mapping Natural Resources Vulnerability to Droughts Using Multi-Criteria Decision Making and GIS (Case Study: Kashkan Basin Lorestan Province, Iran)

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Abstract. Zagros Mountains in west of Iran are covered by unique forests and rangelands. Increasing population, low level of development and high dependence of local people on natural resources for primary livelihood needs resulted in degradation of Zagros forests and rangelands. Along with these factors, since the last decade, climate change including severe drought is an important issue in the world, particularly in semi-arid natural areas of Iran including Zagros. This research was conducted to develop an integrated method for mapping vulnerability of natural resources to droughts in Kashkan basin Lorestan province, Iran in 2015. Hence, a combined method including AHP as a Multi-Criteria Decision Making method and GIS was used. Based on literature review, study area conditions and experts’ opinions, six criteria and nineteen sub criteria were determined. The weights of this initial set of criteria and sub criteria were determined by experts using pairwise comparisons and weights of them were calculated. Then, maps of different sub criteria were analyzed in the GIS environment using calculated weights. Results showed that the most important criteria in drought sensitivity were hydro climate, physiography, and vegetation cover. Annual mean precipitation and temperature, vegetation cover were the most important sub criteria. Findings of research also indicated that 17.11\%, 26.28\% and 7.67\%, of the studied area were classified as low, moderate and high vulnerable areas, respectively. In addition, 8.50\% of the studied area is classified as extremely high vulnerable to droughts. This study introduces a combined method to mapping vulnerability of natural resource to droughts. Findings of this study could be considered by managers to develop proper plans for vulnerable areas.

Key words: Zagros, Drought, Analytical hierarchy process, Rangeland, Forest
Introduction
Zagros Mountains in west region of Iran are covered by unique forests and rangelands. Zagros forests with area of around 5 million ha consist almost 40% of Iran’s forests (Marvi Mohajer, 2013). These forests and rangelands provide a home and livelihood for approximately 10% of Iran’s population (Jazirehi, and Ebrahimi Rastaghi, 2003). Characterized by a semi-Mediterranean climate, they are of the most important and sensitive ecosystems in Iran. Zagros forests and rangelands play an important role in soil and water conservations. About 40% of water supply in the country comes from Zagros region (Ghazanfari et al., 2004) and this fact makes clearer the role of forests and rangelands. Farming in understory, fuel wood extraction, livestock grazing, increasing population, high dependence of local people on forest resources for primary livelihood needs resulted in degradation of Zagros forests and rangelands (Borzoie et al., 2014; Ghazanfari et al., 2004; Jazirehi and Ebrahimi Rastaghi, 2003). Along with these factors, since the last decade, climate change has been becoming an important issue in the world, particularly in semi-arid natural areas of Iran. Drought is one of the climate change symptoms that had affected this region and caused some degradation in forest and rangelands of Zagros. Drought as a climate change phenomena can also effect on rangelands. Droughts can reduce the total annual rangelands forage production (Badri Pour, 2012; Nakhae Nezad Fard et al., 2013) and its consequences are one of the most threats for rangelands exploitation (Sharifyan Bahraman et al., 2014). Drought also has negative impacts on forest hydrology and productivity (Sun et al., 2015). Even when mortality is not realized, severe droughts can have long lasting effects on forests (Anderegg et al., 2015). Many studies investigated severity or consequences of droughts (Esper et al., 2007; Damavand et al., 2016; Safari Shad et al., 2017), but few studies tried to determining vulnerable area to droughts. Determining and mapping of the vulnerable areas to drought can be considered as the first and main step in drought management planning (Pandey et al., 2010; Stone & Russel, 2011; Pasho et al., 2011; Shahabfar et al., 2012). A more structured, systematic approach to assessing the vulnerability could help policy makers and managers develop more realistic approaches (Joyce et al., 2013). This phenomenon can be affected by some different factors including forest structure, land use, irrigation conditions, land cover, species types, annual and seasonal rainfall, standard precipitation index, watershed geography, soil type, water resources positions (surface and sub-surface) and land properties (Allen et al., 2010; Pandey et al., 2010; Pasho et al., 2011; Núñez et al., 2011; Shahabfar et al., 2012; Fang et al., 2012; Liu at al., 2013). This problem needs to be considered by the managers. Managers should prepare suitable precautions to deal with this problem.

However, numerous affecting factors make drought management planning as complex task. Thus, there should be proper tools that can be used to determine affecting factors and zoning vulnerable areas to drought. Multi-Criteria Decision Making (MCDM) methods are decision analysis tools that have been developed in order to support complex decision making (Kangas and Kangas, 2002; Colantoni et al., 2016).

The multi-criteria analysis techniques can greatly reduce the cost and time and increase accuracy in decision-making. Analytical Hierarchy Process (AHP) as a multi-criteria decision making method, has been extensively used in natural resources management. AHP is a quantitative method that uses paired comparisons for weighting criteria and sub-criteria. Along with the rapid progress of GIS and computer