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Making competent land use policy using a co-management framework

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ABSTRACT

A new cooperative watershed management methodology has been designed for developing equitable and efficient Best Management Practices (BMPs) with participation of all main stakeholders. The approach intended to control total sediment yield, stormwater and to improve socio-economic status of the watershed, considering villagers, legislation and executive stakeholders with conflicting interests. Toward this goal, the game theory was used as an alternative tool for analyzing strategic managerial practices and measures among various demands in order to achieve cooperative decision-making in sub-watershed and Best Co-Management Practices prioritization (BCMPs). Hence, the Borda scoring algorithm applied to count the priority of 13 sub-watersheds in the Galazchai Watershed (103 km^2) in West–Azarbaijan Province, Iran. Accordingly, the aforesaid algorithm rated suggested BCMPs by three groups of stakeholders and a factor scoring method was then used to classify 94 proposed practices in three categories. Based on the Borda scoring results, seven sub-watersheds placed in first priority of which five sub-watersheds occupied main rangelands of the study watershed. In addition, the first category of practice included 12 BCMPs of which four measures were related to secondary livelihood source creation, seven practices proposed proper land use management and rehabilitation, monitoring, timely grazing of rangelands, and financial support for rangelands improvement. Finally just one practice emphasized on biological operations in order to control streambed erosion.

1. Introduction

Many environmental issues have been solved in the last three decades through collaborative management (Parrachino et al., 2006a; Koontz and Jens, 2014). Based on environmental and land management incentives, in order to sustainable development, interdependence among involved stakeholders and obtaining local needs are necessary (van Berkel and Verburg, 2011). Besides, it is assumed that environmental public problems are not amenable to control satisfactory except with development of collaborative solutions (Koontz and Jens, 2014; Adhami and Sadeghi, 2016).

The collaborative management is a cooperation process to participate in information collecting, decision-making and accomplishment of projects (Bryson et al., 2013) leading to resolve complex society-environment dilemmas (Leys and Vanclay, 2011). Collaborative approach has been applied in various areas such as policy making (Irvin and Stansbury, 2004), economic development (Agranoff and McGuire, 1998), medical care (Johnston and Romzek, 1999), food security (Carfì et al., 2018), natural disaster management (Seaberg et al., 2017), soil and water conservation (Bewket and Sterk, 2002), landscape management (Leys and Vanclay, 2011), and watershed management (Bryson et al., 2013; Koontz and Jens, 2014; Adhami and Sadeghi, 2016).

Collaborative management has occupied main house in thought and practice of natural resource management since the 1990s (Cundill et al., 2013). Collaborative Watershed management is also crucial to guarantee the ecosystem sustainability. A collaborative watershed management is a process, which includes relevant stakeholders to watershed resources. They interfere in decision-making to achieve ecosystem-oriented goals, such as water quality improvement, soil conservation and pollution control (Üçler et al., 2015; Thomas, 2017). Aforementioned stakeholders involve government participants, policy making institutions and the residents as well (Koontz and Jens, 2014; Shisanya, 2018). All watershed partnerships usually focus on planning tasks. Although collaborative planning may take considerable time, effort, information, and funding but proponents argue leading to advantages over traditional policymaking. One potential benefit is the creation of plans that are more readily implemented (Inam et al., 2015; Pandey and Singh, 2016).

Nowadays controlling stormwater and managing nonpoint source (NPS) pollution are two objectives of water and soil resources conservation in watersheds (Davudirad et al., 2016) for which various best management practices (BMPs) have been implemented (Qiu, 2013).

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The BMPs could conserve soil and water on-site resulted from improvement in watershed resources utilization (Lee et al., 2010; Nobles et al., 2017). The specification of BMPs requires constant involvement of all relevant stakeholders whose attitudes and behavior toward land use and management practices have long-term impact on watershed resources sustainability and also are influenced by the implemented alternatives (Lee, 2012). The effectiveness of BMPs on watershed management will be greatly improved if they come up from stakeholder's consultation upon the same issues. On the other hand, various environmental and socio-economic conditions may lead to conflicts among stakeholders, strategies and policies that cause barriers to proper management (Sadeghi et al., 2009). This approach derived from integrated model hereafter will be named as Best Co-Management Practices (BCMPs).

At present, a watershed is supposed as the basic unit of all research, development and policy-making activities to achieve integrated management of water and land resources. However, watershed is a dynamic unit, its reaction for naturally and man-made driving forces varies both spatially and temporally (Sadeghi, 2005). Recognition of important sites with high priority in term of issue is therefore necessary to develop appropriate strategies in order to abate the issues. To solve such problems, one approach is to identify critical areas of a watershed responsible for occurrence of obstacle in the critical sub-watersheds (Besalatpour et al., 2012; Adhami and Sadeghi, 2016; Naubi et al., 2017).

The BCMPs facilitate collaboration of involved stakeholders to compromise upon conflicts among various attitudes in social, economic and natural resources management (Alves-Pinto et al., 2017; Roth and de Loë, 2017; Thomas, 2017). Issues and conflicts in the context of watershed management often derive from economic benefits resulting from land use development. Sometimes there are parallel benefits on economic and social objectives and in some cases environmental goals (reduction of water pollution) have been apparent as one side of a velitation (Lee, 2012; Skardi et al., 2013; Shiau and Chou, 2016; Gluesing et al., 2017). Hence, Pareto-optimal (non-dominated) and multi-objective approaches may help managers mediate among all stakeholders' demands identifying one or few solutions (Madani, 2010; Lee, 2012; Cohon, 2013; Kim and Chung, 2014; Berthomé and Thomas, 2017).

The game theory, which originated with the work of von Neumann and Morgenstern (1944) is a mathematical tool for analyzing and resolving problems related to conflicting interests (Madani, 2010; Adhami and Sadeghi, 2016; Li, 2018). The conflict includes players (stakeholders) who pursue distinct goals and accordingly select various alternatives from an available set (Madani et al., 2014). From application viewpoint, the game theory is a mathematical interactive decision-making process that attempts to identify optimal strategies between several players whose choices affect the interests of other players (Parrachino et al., 2006b). The game theory has been applied in various velitating fields of science including economics (e.g., Ichiishi, 2014) and sociology (e.g., Lee, 2008; Colman et al., 2008). It has also been used in water resources management (Parrachino et al., 2006a, 2006b; Madani, 2010; Kucukmehmetoglu, 2012), water resources and rights allocation (Eleftheriadou and Mylopoulos, 2008; Jalili Kamjoo and Khosh Akhlagh, 2016), water reservoir operation problems (Shirangi et al., 2008), and management of water-quality issues (Shi et al., 2016).

Reviewing of the literature showed that the application of game theory as a voting support system to reduce conflicts of decision-makers in watershed management (e.g., Adhami and Sadeghi, 2016) has been rarely reported. However, Watershed management encircles conflicts arising from opposing interests or needs of stakeholders. Hence, because of multitude watershed management objectives with increasing competition for watershed resources, single task decision-making process is replaced with conflict analyzing approaches specifically game theory (Apipalakul et al., 2015; Adhami and Sadeghi, 2016). Most of literatures cite analysis of environmental and economic conflicts applying game theory (Lee, 2012; Üçler et al., 2015; Zarezadeh et al., 2016). While, the different attitudes of various groups of beneficiaries have been mostly ignored. The voting procedure is simple and transparent for voters without need to severe computational difficulties. Thereby, this algorithm of game theory is an appropriate tool for group-decision-making. However, one of the disadvantages of current method is inability to determine the alternative that would provide the most satisfaction of stakeholders. In the other words, it is not possible to bargain and reach a maximum deal.

As it is seen from the reviewing of literatures, the concepts of game theory such as non-cooperative (considering the strategies interaction among the players and to decide based on the maximization of their payoffs) and cooperative (focusing on agreement among the players and to equitably and fairly allocate cooperative payoffs) have been applied to water resources field. However, no study has used game theory to prioritize different sub-watersheds based on BCMPs with the agreement of political, executive and villager (watershed inhabitants and utilizers) stakeholders. This study therefore planned to apply the game theory to provide clear choices for different decision-makers to select appropriate alternatives that balance socio-economic, political and even technical development in the Galazchai Watershed, Iran. The results of this study may not only be directly used for the study watershed but can be supposed as an initiative to expand the application of game theory in integrated watershed management, revision in legislation and even implementation of appropriate soil and water conservation measures.

2. Materials and methods

2.1. Study area

The Galazchai mountainous watershed ($\approx 103\ km^2$; between 44° 56′ and 45° 35′E longitudes, and 37° 01′ and 37° 09′N latitudes) in West-Azarbaijan Province, Iran, was selected for the present study due to availability of background research (Mostafazadeh et al., 2015; Sadeghi et al., 2015a, 2015b; Mostafazadeh et al., 2016; Saeidi et al., 2016), data availability, and possibility of frequent field surveying. The length of the main stream is some 19.3 km, and the average watershed slope is approximately 32%. It also extended between 1480 and 3300 m above mean sea level. The area is steep and prone to soil erosion and flooding. The average annual precipitation (1981–2010) at Oshnavieh meteorological station in the vicinity of the main outlet is 482 mm (Ab Banan-Azardasht Engineering Consulting Inc., 2010). The governing climate of the study watershed is dry semi-arid with annual average temperature of 11.8 °C (Ab Banan-Azardasht Engineering Consulting Inc., 2010). Different land uses viz. rangelands (85%), forest (7%), rainfed farming (5%) and irrigated farming (3%) exist in the watershed (Sadeghi and Singh, 2005). The study area has been divided into 13 sub-watersheds based on drainage network using Arc Hydro extension in GIS environment. The general view and locality of the Galazchai watershed has been shown in Fig. 1.

2.2. Data sources and analysis

The whole data for the study were collected for three main stakeholders containing watershed inhabitants, governmental organizations or technical sector and also local politicians or government representatives. The major source of data was a formal household survey conducted between August and September 2016. To conduct the research, two villages in the study watershed viz. Galaz (with 282 households) and Zemmeh (with 100 households) respectively located in upstream and downstream of the watershed (Fig. 1) were considered. The lists of households in each village were then obtained from the respective Village Council. A total number of 243 samples (i.e., 163 and 80 samples from Galaz and Zemmeh, respectively) were selected from the entire households using Cochran's criterion (Cochran, 2007). A random sampling procedure (Jia and Barabási, 2013) was also selected