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THEMATIC ISSUE

Strategies and policies for water quality management of Gharasou River, Kermanshah, Iran: a review

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Abstract

Water quality of rivers depends on land use, sediment load, natural hazards such as flooding and drought, water pollution and eutrophication, and multiple use. The water quality management of the Gharasou River in a basin-scale approach was reviewed. Both non-point and point sources were investigated in terms of management, land use, and patterns of land use change, soil erosion and sediment load, the changes of water compositions, and sources of water pollution. The role of local farmers in planning and implementing management strategies and policies and vulnerability management was also reviewed. The results showed that in the Gharasou River Basin, conversion of rangelands to rain-fed lands is the main factor that produces sediment loads in the hilly area as they are the most sensitive areas to soil erosion. Sub-basins producing the most considerable runoff and sediment in the main outlet are now evident. The position of point pollution sources and sources responsible for non-point pollution of the Gharasou River is determined. Conversion of rain-fed lands to forest, prohibiting improper agricultural activities, organic farming, government investment for rangelands, wastewater treatment plants, phytoremediation, considering the factors for vulnerability management of drought, and participation of rural communities are suggested as some management strategies and policies for water quality management. This study is likely to help government and policy-makers to have a realistic picture of the water quality of the Gharasou River, its problems, and the reasons responsible for present conditions. The government and policy-makers could/should plan and fulfill the best policies regarding local peoples' needs and participation to manage natural resources such as soil, water, and land cover/land use.

Keywords Soil erosion/runoff · Land cover/land use · Management policy · Management strategy

Abbreviations

KRB	Karkheh River Basin
SOM	Soil organic matter
UFR	Unite flood response
WHC	Water holding capacity
SWAT	Soil and water assessment tool model
TSS	Total suspended solid
LP	Linear programming
RMCs	Rangeland management cooperatives
WUA	Water users association
IMT	Irrigation management transfer
MoAJ	Ministry of Agriculture Jihad
MoEF	Ministry of Environment and Forest

Introduction

Water quality is not only essential for the growth and health of human populations but also affects the ecological health of basin systems. On a basin-scale, water quantity and quality moving downstream are affected by upstream changes. Therefore, a basin-scale approach is essential to water quality management (Hessari et al. 2012). Karkheh River is the third major river in Iran that originates from the Zagros Mountains and flows into the Persian Gulf (Fig. 1). The Gharasou River is the primary resource of water supply for the Karkheh River Basin (KRB) (Fig. 2). KRB is one of the major basins in western Iran. Furthermore, the KRB is a vital basin as a water supply for some parts of Kurdistan, Kermanshah, Hamadan, Lorestan, Ilam, Markazi, and Khuzestan provinces (Haghiabi and Mastorakis 2009; Samadi

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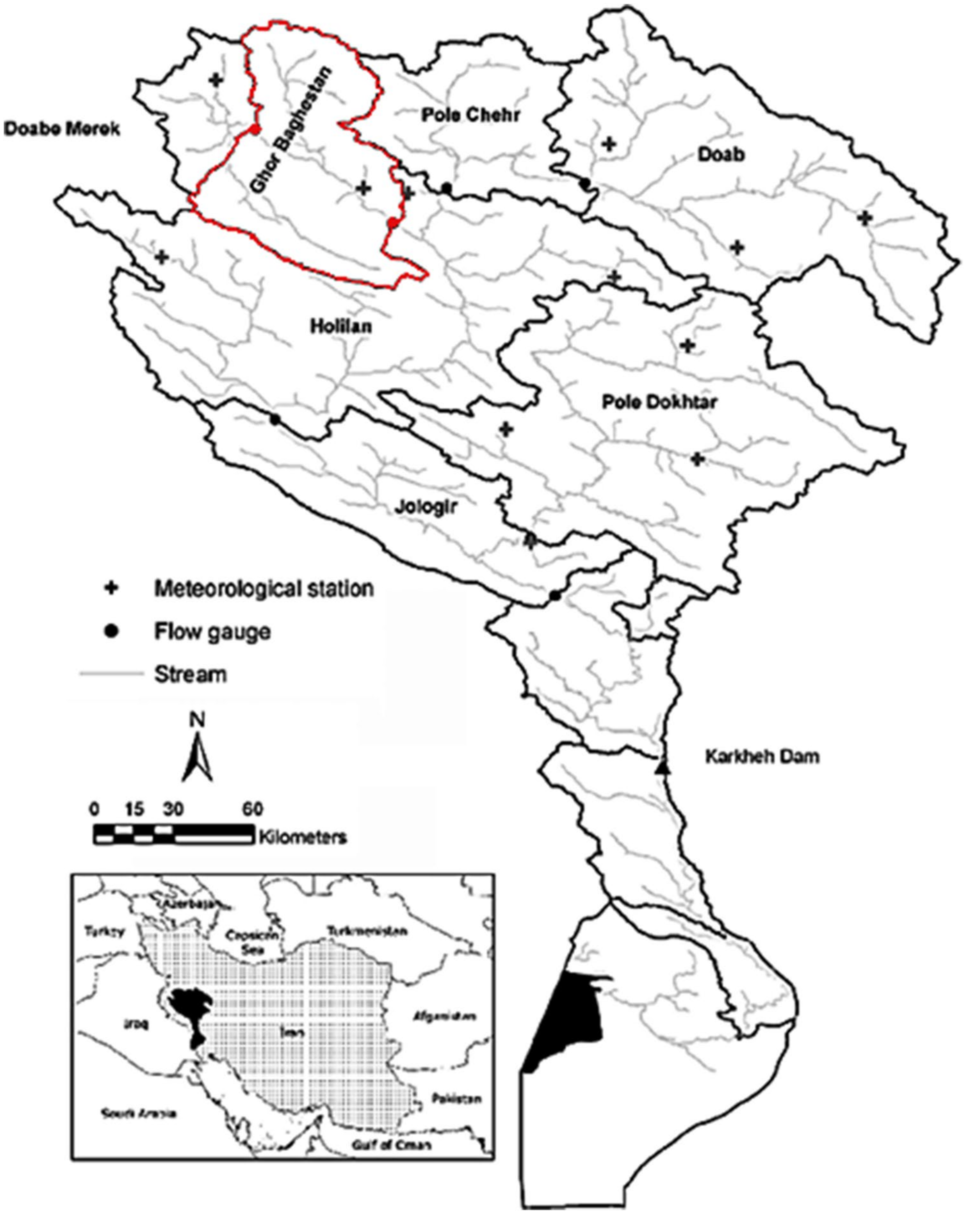

Fig. 1 Karkhe River Basin (KRB) location in Iran (Rientjes et al. 2013)

et al. 2013). KRB with an area of 51,000 km^2 is located at 30° to 35° N and 46° to 49° E (Rientjes et al. 2013). The five sub-basins of the main rivers in the KRB include Gamasiab, Gharasou, Kashkan, Saymareh, and Karkheh (Ahmad and Giordano 2010). The main challenges of soil and water management in KRB are low crop production, poor management of land and water resources, and small-scale irrigation performance (Haghiabi and Mastorakis 2009).

The water quality of the KRB predominantly depends on land use and the patterns of land use change. Prioritization of land for the target programs and policies to achieve maximum benefits is a critical factor in basin-based approaches in Iran (Mahmoudi et al. 2010). However, there are conflicts among stakeholders, strategies, and policies because of various environmental and socio-economic conditions. Under this circumstance, the basin management could not be effective unless the overall optimal land and water use are justified throughout the entire basin. An assessment of land use and erosion change patterns is useful to provide an extensive and comprehensive analysis. This assessment, which incorporates individual system components within a general framework, is better than the one that examines them in isolation. By prioritizing land use, limited resources are allocated to the areas which have the potential to or damage basin health. Therefore, the basin will be kept healthy with economic efficiency (Mahmoudi et al. 2010).

Water quality management would be effective when sediment load and spatial prioritization studies are considered as screening tools (Saghafian et al. 2012). Floods and droughts represent the main hydrological hazards in the Gharasou

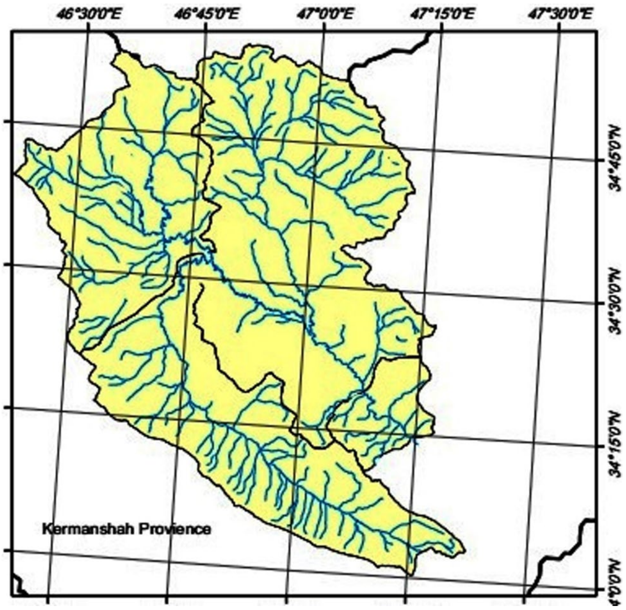

Fig. 2 Gharasou River Basin in the northwest of KRB (Hosseini et al. 2016)

River Basin (Samadi et al. 2013). In the KRB, the risk of flooding and soil erosion is much higher when rainfall is enhanced (i.e. expected in both spring and autumn) (Solaymani and Gosain 2015). Surface erosion and sediment yield should be considered as essential factors in planning renewable natural resource projects (Hosseini and Ashraf 2015). The best management practices (BMPs) could be planned and designed by the identification of critical resource areas within the basin. In this approach, based on runoff yield and sediment load indices, critical sub-basins are ranked and prioritized. Afterward, soil and water conservation will be performed by this ranking. As a result, decision-makers use more effective conservation practices where they are needed most. The result is the improvement and effectiveness of water quality programs by controlling sediment production (Saghafian et al. 2012).

Extreme pollution might occur during single flood events (Buck et al. 2004). However, during consecutive drought years, the quantity and quality of water resources will also be lost by the extraction of underground waters (Haghiabi and Mastorakis 2009). Besides, purifying of the polluted resources is highly unlikely to occur. The changes in the chemical composition of the groundwater quality of the Gharasou River Basin depend on rainfall, water harvesting, and the type of soil (Soltanian et al. 2015). Furthermore, as human population increases, agricultural areas and industrial units need more water.

Managing a river basin is a difficult task because of keeping a balance between environmental flows and the inhabitant's demands, which are usually in conflict (Sadeghi et al. 2007). Competition between various uses of water is one of the significant issues in the middle of the KRB (Haghiabi and Mastorakis 2009). Giving local users a role in managing their basin resources leads to projects that are more efficient and effective than their top-down predecessors (Johnson et al. 2002). Without close participation of users, any policy and management scheme is likely to fail or succeed partially (Jalali and Abadi 2018). Prager et al. (2011) indicated that optimal and flexible policies would allow farmers to select the essential work after the determination of anticipated results. The desired output can be achieved by leaving the responsibility to farmers considering their needs, providing advice, and controlling the implementation.

This paper reviewed published papers related to the management of the Gharasou River Basin regarding the issues mentioned above.

Materials and methods

In this study, local databases including Irandoc, and SID along with the international databases such as Google Scholar, Springer, Elsevier, Taylor and Francis, and Wiley online library were explored. In a primary step of searching the papers, it has been evident that there were different spellings of the Gharasou River. The results showed that there are 478 papers with spellings such as Qaraso, Qarasou, Gharasu, Gharasoo, and Gharaso. Moreover, there are two different rivers with the same name, which are located in Golestan and Ardabil provinces in the northern and northeast areas of Iran, respectively. Therefore, the papers, which are related to the Gharasou River in Kermanshah province, were selected. Also, the studies which included the Gharasou River Basin as a sub-basin of KRB were considered. Besides that, the papers related to sub-basins of the Gharasou River Basin were also examined. The key terms for this study include "water quality", "soil erosion", "land cover/land use", "management", and "policy". The collected publications are 32 papers published from 1990 to 2019 about management strategies and policies for rangelands fulfilled in Iran.

General description of the study area

The area of the Gharasou River Basin is 5793 km^2. The topographic relief of the Gharasou River Basin ranges from 1237 to 3350 m, with a mean elevation of 1555 m (Omani et al. 2007). The average annual rainfall of this basin is about 447 mm and ranges from 215 to 785 mm. The most rainfall takes place in February and the least in July. The annual mean temperature is about 14.6 °C. The warmest and the coldest times of the year take place in July and January with an average temperature of 26.95 °C and 1.15 °C, respectively. However, these temperatures could increase to a high of 37.8 °C and decrease to a low of − 4.2 °C in these months. Besides, the annual mean potential evaporation is 2132 mm (Hosseini et al. 2016; Omani et al. 2007; Samadi et al. 2013).

Results and discussion

Land cover/land use management

In the Gharasou River Basin, irrigated agriculture is concentrated in the alluvial areas with gentle slopes and productive soils. The erosion is slight in these regions due to the gentle slope, dense soil texture, and higher soil organic matter (SOM) contents (Heshmati et al. 2012). However, the land use of the hilly area is a critical factor, where rangelands are converted to rain-fed lands for agricultural purposes. A considerable portion of the rain-fed lands is located in the hilly area. This area has low to medium resistance to erosion. As a result, more sediment yield will be produced in hilly areas (Yaghobi et al. 2014).

In the mountainous area, steep slope is the main factor of erosion. Omani et al. (2007) suggested some management practices for soil conservation concerning the topographic conditions and the possibility of land management practices. Omani et al. (2007) suggested (i) support practices (contouring and terracing) and (ii) changing the land cover in hilly and mountainous areas regarding land suitability studies. They also suggested that "contouring" or "contouring and terracing" are suitable to reduce sediment loading for the critical sub-basins of the Gharasou River Basin. Furthermore, the runoff and sediment yields simulated by the SWAT model showed that contouring and terracing of rain-fed lands in hilly areas are more effective than just contouring. However, Yaghobi et al. (2014) reported that contouring and terracing are impracticable or costly or have an adverse effect on the output peak discharge. Therefore, they recommended land use conversion of hilly and mountainous areas for soil conservation.

The reduction of sediment yield in mountainous sub-basins is negligible; therefore, land use conversion is not practical. The best and effective land use conversion will be expected for hilly areas in which rain-fed lands are the predominant land use. Conversion of rain-fed lands and other land uses in hilly areas to forest (or orchard), pasture and rangeland, are considered as the best land use conversion. Conversion of the rain-fed area to orchards and woods in the steep slope of hilly sub-basins will reduce erosion about five percent (Omani et al. 2007). Changing the ranges from third class into first and second classes and agricultural optimization are the other low-cost agricultural practices (Yaghobi et al. 2014).

Soil erosion/runoff management

Saghafian et al. (2012) applied the unite flood response (UFR) technique to prioritize sub-basins of the Gharasou River Basin. In this technique, a unit of runoff and sediment is removed, and then the response of the outlet of the basin to this change is determined. The result indicated the contribution of each unit. Within UFR, runoff and sediment at the sub-basin scale are determined. Also, the effect of runoff and sediment routing throughout the basin up to the main outlet is incorporated. For model calibration and validation, they used total suspended solids (TSS), measured monthly for large samples over 11 years in several locations within the basin. The UFR results were completely different from those based on single sub-basin water and sediment yield at the sub-basin outlet (Saghafian et al. 2012). The first and last ranking of sub-basins in the total runoff and sediment are not related to the highest or lowest absolute runoff and sediment load at contributed sub-basin outlets. On the other hand, the nearest sub-basins to the outlet, compared with the most distant, do not have the most significant influence on the discharge and sediment yield. Many factors that influence the functions describing basin discharge and sediment response are not linear. According to the results of this study, the highest runoff and sediment production at contributed sub-basin outlets related to two sub-basins 16 and 3. UFR-based simulated runoff and sediment yield indices showed that sub-basins 2 and 4 produced the most considerable runoff and sediment in the main outlet (Fig. 3a) (Saghafian et al. 2012). A comparison between maps produced by Saghafian et al. (2012) and Omani et al. (2007) indicated that sensitive sub-basins to soil erosion (Fig. 3b) are similar to sub-basins with the highest sediment yield production. However, the estimation of sediment yield is different. Omani et al. (2007) estimated sediment yield in sensitive sub-basins to soil erosion from 5.1 to 11.8 ton ha^{-1}. Saghafian et al. (2012) estimated sediment yield as 1.2–3.8 ton ha^{-1} for 6 sub-basins producing a higher amount of sediment yield (Fig. 3a). The difference might be related to the duration of these studies. While Omani et al. (2007) study lasted for 20 years (1980–2000), Saghafian et al. (2012) study took 11 years (1990–2000).

Natural water compositional changes and water management

To minimize the changes in natural water composition, Haghiabi and Mastorakis (2009) suggested some solutions as follow:

(i) water treatment to provide safe drinking water for cities and industries as well;

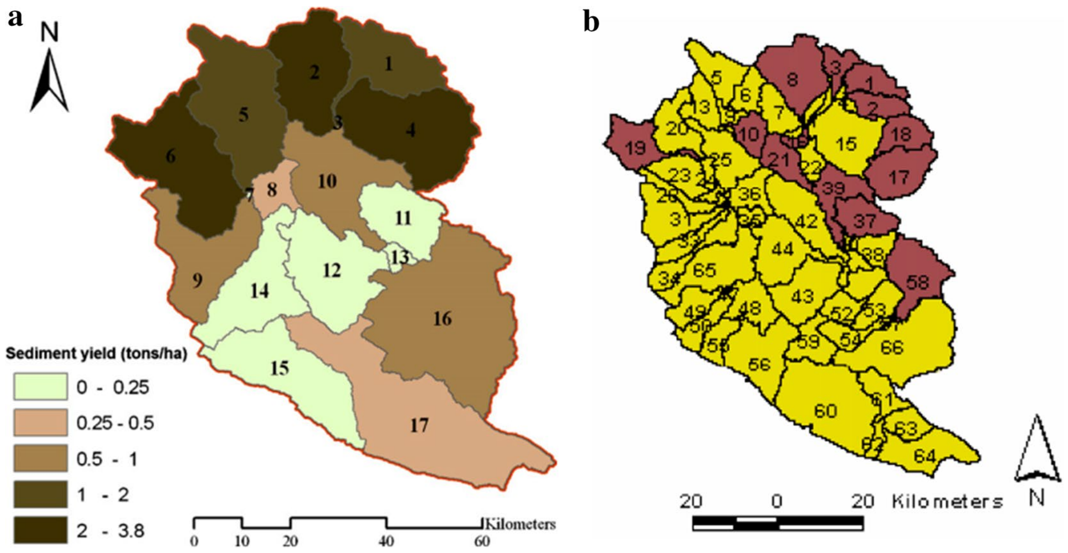

Fig. 3 Comparison between **a** sediment yield estimated by (Saghafian et al. 2012), and **b** estimated sensitive sub-basins to erosion (dark color); sediment yield ranged from 5.1 ton ha^{-1} related to sub-basins 8 and 37–11.8 ton ha^{-1} related to sub-basin 2 (Omani et al. 2007)

(ii) the construction of a dam and substantial investments by the government;
(iii) the enhancement of water productivity of the irrigated and rain-fed crops by the construction of irrigation and drainage networks and water supply channels;
(iv) the development of sustainable management practices such as encouraging the cultivation with less water demand, improving cropping systems, and managing crop.

Considering these recommendations lead us to benefit from water-relative opportunities in the agricultural economy. Maximizing the net economic profit depends on several environmental and logistical limitations such as available water and area of the farms among others. However, net economic benefits would be possible by finding the optimum cultivation patterns (Zare and Koch 2014). It is a complicated issue and usually requires the methods of constrained optimization such as linear programming (LP) models. For this purpose, they selected 100 hectares of farmland on the border of the Gharasou River. The study area was cultivated by eight major crops including wheat, barley, maize, sunflower, soybean, alfalfa, canola, and sorghum, which were irrigated by groundwater from seven wells. The net profit was calculated by incomes (selling price of the product on the market) minus costs (irrigation, fertilizer, farm rent, and transportation of the crops). The results of the LP-constrained maximization indicated that the optimum cultivation pattern, which increases economic benefits annually, equals 11.3 percent compared with the present cultivation pattern. Zare and Koch (2014) also carried out a sensitivity analysis for cultivation patterns to examine if additional water could be saved beyond the given water-volumes limitations. The results showed that 52,878 m^3 year^{-1} of water (equal to 11.9 percent of the total available water) could be collected without any significant decrease in the net profit. They illustrated that the net profit would decrease theoretically. However, the net profit will be mainly compensated by saving water, which is a very scarce resource in the study area. According to this study, wheat is placed first in rank, followed by barley and maize, respectively. Moreover, sunflower and soybean cultivations are not economical and should be omitted entirely from the future cultivation pattern. While the areas of wheat and barley crops should be increased, those of the other plants should be decreased or left unchanged (Zare and Koch 2014). Sustainable water resource development also required conjunctive management of surface–groundwater resources, especially in water-scarce regions. For this purpose, mathematical optimization-simulation techniques turn out to be an essential issue (Zare and Koch 2017).

Zare and Koch (2017) determined the optimal agricultural irrigation water allocation in the Miandarband Plain by simulation models. The Miandarband Plain is located in the Kermanshah province with a surface area of about 300 km^2. The Miandarband Plain is geographically limited in the North by the Gharal and Baluch mountains and in the South by the Gharasou River. In the Miandarband Plain, 90% of the available water resources are used by agriculture, which is supplied by the Gavoshan dam (Zare and Koch 2017). Zare and Koch (2017) considered the politically prioritized proportions of the Gavoshan dam, which allocates water for domestic, environmental, and agricultural uses. They obtained 112 MCM a^{-1} as the optimal monthly water available for agriculture in the Miandarband Plain. Based on the present agricultural pattern in the Miandarband Plain, they calculated the irrigation water demand by the FAO-56 method. The results indicated that the irrigation water demand was estimated as 265.8 MCM a^{-1}. Therefore, the 153.8 MCM a^{-1} irrigation water shortages can be made up of groundwater. This estimation was reported for conditions when water is used in an efficient system; without any waterlogging of soil or creating a severe drop of groundwater level (Zare and Koch 2017).

Management of non-point and point pollution sources

Pollution processes, natural or anthropogenic, are responsible for rapidly declining water quality (Ağca 2014; Zhou et al. 2013). The pollution sources of water can be categorized as point and non-point. Point sources' pollution consists of pipes, wells, or channels. Non-point pollution sources include atmospheric deposition, agriculture, forest, mining, construction, municipal, and residential sources.

Rezaei and Sayadi (2015) reported that agricultural activities are non-point pollution sources for the Gharasou River. Modification or adaptation of farming practices such as reducing insecticides spray, applying lower amounts of chemical fertilizers, and creating less drainage decrease water pollution (Hosseini and Ashraf 2015).

For combating point pollution resources, two strategies are suggested: wastewater treatment plant (Fereidoon and Khorasani 2013) and phytoremediation (Ahmadpoor et al. 2015).

Wastewater treatment plants could be designed as bacteria farms to consume organic waste by bacteria under aerobic conditions (Fereidoon and Khorasani 2013). Thanks to the preliminary studies run by Fereidoon and Khorasani (2013), we already know the best location of wastewater treatment plants regarding economic and environmental conditions. The simulated results by the QUAL2K model showed that the treatment of wastewater could not significantly decrease the total nitrogen (TN). As a result, the decrease of TN cannot be considered in wastewater treatment. Conversely, for total phosphorus (TP), wastewater treatment has economic benefits (Fereidoon and Khorasani 2013). Hosseini and Ashraf (2015) suggested filtering and removal of nutritious elements of sewage or deviation of sewage path as the subsequent management strategies.

Ahmadpoor et al. (2015) evaluated the possibility of eliminating or decreasing excess nitrate and phosphate from water in hydroponic conditions. They selected watercress (*Nasturtium officinale*) and pennyroyal (*Mentha pulegium*) plants because of their adaptability with most climate conditions in Iran and fewer care requirements. Results indicated that two plants purified nitrate and phosphate in polluted water. Consequently, contamination of the water body and environmental pollution will be prevented by the recovery of N and P. This result is more critical about P, whose cycle is slow in the environment. Later, these plants can be used as organic resources for N and P in agricultural lands as green manure (Ahmadpoor et al. 2015).

Policy-making

Blaikie (1989) mentioned a national conservation strategy or a conservation project in terms of technical aspects of degradation, mapping, improved management techniques, and extension. Policy documents should take into account other issues beyond them. He also explained the reasons for the poor performance of many policies and projects. The economic analysis of the costs and benefits of the project is based on assumptions which Blaikie (1989) believes are false. These assumptions are (i) land users will pay attention to extension advice and obey any enacted legislation, and (ii) the political will, administrative capacity, and legitimacy of the government of the day promote the policy.

According to the selected issues chosen in water management, the related publications were reviewed, and policies suggested in "Land cover/land use" to "Monitoring". These issues include land cover/land use, soil conservation, flood, drought, climate change, water pollution, and the role of water users' participation in water management.

Land cover/land use

To build an effective water management policy, we must provide answers to the questions below: (i) Is serious degradation taking place? (ii) Who will be affected by land degradation? (iii) Why is land degradation taking place? (iv) What are the solutions and how to reach them (in other words, a policy) (Blaikie 1989)?

For the Gharaou River Basin, the answers of the above questions are:

(i) Land degradation was taking place as evidenced by studies of Heshmati et al. (2012) and Gheitury et al. (2019) for the Merek and Mahidasht sub-basins, and even in unstudied sub-basins.

(ii) Blaikie (1989) mentioned three groups involving a mapping exercise of lands (either being degraded or at risk), the land users' responsibility, and who pays the costs of degradation. The costs consist of increasing sediment in rivers, lakes, and irrigation systems, increasing flooding in the wet season, decreasing flows in the dry season, and chemical degradation of downstream soils in some cases.

(iii) The conversion of rangeland to rain-fed crops, overgrazing, and deforestation are the main reasons for land degradation in the Gharasou River Basin (Abu Bakar et al. 2015; Heshmati et al. 2012; Omani et al. 2007). Mashayekhi (1990) presented a comprehensive overview of the reasons for land use change and overgrazing of rangelands in Iran. He pointed out that the demand for agricultural products and meat increased after the revolution of 1977. The reasons included the growing population, gross national product (GNP) per capita, and foreign exchange restrictions, which decreased meat import for 2 years. The imbalance between the demand for meat and food and importing led to the rise of meat prices which in turn increased the number of meat-producing animals rapidly. Subsequently, hay was produced domestically on farmlands and rangelands. Rangelands are nationalized and free of charge to use in Iran. Moreover, profitable meat production resulted in more animals moving into the rangelands. The imbalance between the rangelands capacity and animal population in the rangelands along with grazing the immature grass left no opportunity for recovery of the overcrowded rangelands. Azadi et al. (2009) reported three significant components in a pasture to define sustainability in range management in three different areas of Fars province, in southwest Iran. They reported that the stocking rate, the plantation density per hectare, and the pastoralists' population are important indicators. Rangelands' destruction and a decline of total rangelands at an accelerating rate started in the early 1970s because of the sharp fall of grass availability (Mashayekhi 1990).

(iv) Mashayekhi (1990) suggested that the best solution for decreasing land use changes, overgrazing, and land degradation is government investment. Investment improves the conditions of the rangelands, and more grass becomes available. By increasing government investment about tenfold, the development will occur, and the destruction of rangelands would continue at a lower net rate. However, limitations such as budget constraints and implementation concerns are doubtful (Mashayekhi 1990). Arnalds and Barkarson (2003) reported that the part of the production government subsidies dedicated to sheep farmers in Iceland was tied to "quality management", including sustainable land use. Results showed that grazing pressure on marginal highland areas was eliminated by linking subsidies to land conditions and improvements. However, Arnalds and Barkarson (2003) reported that it is not expected that subsidies lead to the prohibition of such grazing practices. Also, Fleskens and Stringer (2014) suggested that credit facilities dedicated by policymakers enable land users to adopt sustainable land management practices.

Jalali and Abadi (2018) investigated factors that have a direct effect on rangers' participation in institutions such as Rangeland Management Cooperatives (RMCs) in the northwest rangeland of Iran. They reported that job satisfaction and progression are the most critical factors. Job satisfaction indirectly influences participation, whenever the economic conditions of the local industries developed by the RMCs' officials. Furthermore, RMCs improved other skills, such as proper interrelation, acceptance, progressivism, optimism, and cost–benefit (Jalali and Abadi 2018).

Another solution is the prohibition of changing the natural land cover on hilly areas to farmlands. Omani et al. (2007) and Yaghobi et al. (2014) suggested that the present farms on hilly areas should be converted to orchards and woods, and third class ranges into first and second classes.

Agricultural optimization, such as organic farming, reduces soil erosion. Calcareous soils which are dominant in Iran have medium (40%w/w) water holding capacity (WHC), and low (< 1%) SOM content (Malakouti 2008). When SOM increases, WHC increases and soil loss decreases. Mosayeb et al. (2011) reported factors contributing to the reduction in SOM and soil aggregate stability in the Merek sub-basin. Forest clearance, conversion of the rangeland and forest to rain-fed areas, overgrazing, crop residue burning, improper tillage practice (up-down the slope), over-application of chemical fertilizers, and continued annual crop cultivation are the critical factors. Field surveys indicated that the improper tillage practices and over-application of chemical fertilizers are the main reasons for SOM loss in the rain-fed areas and irrigated lands, respectively (Mosayeb et al. 2011). Using chemical fertilizers, especially unusually high levels of nitrogen fertilizers, accelerate SOM destruction by microorganisms. Montanarella (2015) highlighted that tilling less, installing windbreaks, and planting along slope contours decreased soil erosion in US cropland by 43% between 1982 and 2007. Arnhold et al. (2014) reported that herbicides are not applied in organic farming in which weeds can develop; therefore, the ground cover increases compared to conventional farming.

Organic farming for small-scale farmers in developing countries has environmental, economic, and social advantages. Environmental advantages include environmental protection and higher resilience to environmental changes. Economic advantages include increasing farmers' income and reducing external input costs. The social aspects consist of enhancing social capacity, increasing employment opportunities, and enhancing food security primarily by increasing the food purchasing power of local people. In the meantime, the disadvantages of organic farming should also be considered. These disadvantages are lower yields in comparison to conventional systems, difficulties with soil nutrient management, certification, market barriers, and the educational and research needs of small holders. However, by summation of the advantages and disadvantages of organic farming, it should still be considered as a part of the solution (Jouzi et al. 2017).

Soil conservation

Amongst increasing stressful issues that the world is grappling with, such as population growth, food security, and climate change, soil assumed a critical role (Montanarella 2015).

Tiwari et al. (2008) indicated that planners and policymakers should consider the farmers' situation, such as their interest, capacity, and limitation in promoting improved soil conservation technology. Soil conservation technology enables local farmers to adopt technology conducive to increasing income and enhancing soil conservation as well. Their analysis of the logistic model showed some factors that significantly influenced soil conservation technology. Significant factors were farm size, education, the caste of the respondent, membership of the conservation and development user group, and economics (net income from vegetable farming, family member occupation, and use of credit). Understanding the relationship between these factors and the process of adoption of new technology is essential to improve farm production and sustainable land management (Tiwari et al. 2008).

Without policy intervention, it is difficult to find the best farming practices for soil conservation to be adopted by farmers (Prager et al. 2011). Prager et al. (2011) mentioned four properties that policies should include (i) clearly defined objectives, (ii) able to easily link policies to technical measures, (iii) define actor groups directly for the empirical survey, and (iv)combine components of instruments, institutions, and governance structures instead of one category only.

Prager et al. (2011) also explained that farmers are dealing with two contradictory approaches to land use: long-term sustainable use vs. short-term use with a maximum profit. Therefore, even though farmers are effectively aware of soil conservation, they cannot pay any attention to other issues. Policy intervention should be a connection between the long-term nature of soil degradation processes and the short-term policy cycle.

Floods, drought, and climate change

The impacts of drought, desertification, and climate change are closely interlinked (Stringer et al. 2009). With this knowledge, this section has focused on water management regarding flood, drought, and climate change in the Gharasou River Basin.

Thanks to spatial prioritization studies, the critical regions responsible for soil erosion and sediment yields are now evident in the Gharasou River Basin (Fig. 3). Government and decision-makers would donate the best strategies discussed previously in "Land cover/land use" and "Soil conservation". The constructions, such as dams, which draw the floods, can be considered as well.

Drought, however, is a natural and slow-onset phenomenon. To decrease drought damages to agricultural communities, decision-makers should design a management approach to mitigate the harmful impacts of drought (Zarafshani et al. 2016). Stringer et al. (2009) emphasized that policy consists of climate change, desertification, and drought in a more joined-up development context to reduce vulnerability and increase resilience. Zarafshani et al. (2016) similarly suggested that drought policy-makers allow for more participation of local farmers in planning and implementing drought recovery management. They indicated that effective drought management strategies are those designed based upon vulnerability management, which increases farmers' ability to challenge the impacts. Zarafshani et al. (2012) indicated that the assessment of "who" is vulnerable and "why" is one of the main aspects of drought mitigation and planning. This assessment recognizes the interactions between drought hazard and vulnerability that define the risk of severe impacts. Zarafshani et al. (2016) assessed drought vulnerability in Kermanshah province to prioritize limited resources in the design of vulnerability-reducing interventions. They considered three areas with different drought intensities, including very high, extremely high, and critical. They interviewed 370 wheat farmers selected through a multistage stratified random sampling method and who experienced drought during 2007–2009. The vulnerability indices of wheat farmers during drought were assessed by Me-Bar and Valdez's vulnerability formula (Me-Bar and Valdez 2005). Zarafshani et al. (2016) reported that economic, socio-cultural, psychological, technical, and infrastructural factors are the farmers' vulnerability indices. An earlier study by Zamani et al. (2006) analyzed the individual, household, and community responses to drought from a psychological, sociological, and anthropological perspective. At the individual level, psychological characteristics are responsible for drought responses. Psychological aspects include the primacy of loss, the notion of primary and secondary losses, and vulnerability based on prior resourcefulness of the victims. At the community level, since drought severely depletes community resources, the community has fewer resources to recycle over time. Community response to drought is to prevent or respond to resources' loss during hard times. Coping with drought could be conducted as interventions by teaching the victims via well-developed agricultural extension systems that are familiar with stress reduction techniques. Moreover, cooperatives for using water efficiently by the introduction of drought-resistant crops by farmers to make better use of their water resources (Zamani et al. 2006).

For water management, Hassan et al. (2007) noticed the transfer of management responsibility to users by the local authorities. They revealed that the government could encourage the promotion and creation of a Water Users Associations (WUAs). At the local level, water management is coordinated by traditional local authorities who are simultaneously members of the users' community and WUA. This corporation leads to devolving irrigation system management responsibility and administration at the local (sub-system) level. Indeed, by irrigation management transfer (IMT), the operation and maintenance will improve; water losses reduce, and sustainability of irrigation infrastructure enhances (Hassan et al. 2007). They reported the valuable information of the IMT activities in Kermanshah province. The WUA in Kermanshah province is one of two big pilot projects being carried out in Iran. It is located in the Gharasou River and organized along with the territorial principles of villages. The study area, Ravansar, is located in the center of Sanjabi Plain. The water resources used for irrigation purposes in Ravansar include surface resources, springs, and groundwater. However, the primary irrigation resource, especially during the dry season, is the Gharasou River. A team from the Bureau of Extension of the Ministry of Agriculture Jihad (MoAJ) carried out the field visit (Hassan et al. 2007). Their results revealed that in the Ravansar irrigation system, WUAs were not clear about the respective roles of two principle ministries: Ministry of Environment and Forest (MoEF) and MoAJ. MoEF is in charge of water supply, and MoAJ provides advice on crops. Thus, farmers' problems remained unsolved because they do not know where they can find proper solutions for their problems. Furthermore, the objective of WUAs is not clear, which led to the inappropriate intentions of the central government to improve water management through the participation of local farmers. As a result, the failure of successful WUAs originated from two reasons: (i) real participation by farmers has not happened, (ii) there is no reliable water supply by MoEF (Hassan et al. 2007). They proposed that MoEF needs to ensure a steady water supply before involving farmers in water management. Consequently, the incentives of water users might be enough to participate in WUAs.

Non-point and point pollution sources

A number of solutions are recommended to reduce different types of water pollutions (heavy metals, nitrate, phosphate, etc.) for different types of water uses:

(i) prohibiting animal feedlots and wastewater discharge, (ii) establishing effective sewage treatment plants especially in cases of Sahra dairy company (Fereidoon and Khorasani 2013) and petrochemical- and oil-related facilities (Atazadeh et al. 2007) or phytoremediation (see "Management of non-point and point pollution sources"), (iii) imposing restrictions on the application of pesticides, and (iv) determining corrosion rates for pipelines and controlling it.

Education and local organizations

Educating people is critical for water management at the basin scale, Hosseini and Ashraf (2015) reported that land use and the risk of natural resources and their reserves was influenced by the education of the population in the Taleghan basin, Iran.

Jalali and Abadi (2018) believe that to increase rangers' participation in RMCs, RMCs' officials must upgrade intercommunication skills by training. However, institutional variables cannot be ignored in the adaptation of policies, even if they are more important than resource endowment and geographical variables (Tiwari et al. 2008). Johnson et al. (2002) indicated that the role of researchers should be defined both conceptually and in practice.

Johnson et al. (2002) pointed out the importance of having different actors with different skills and interests to participate in high-level research. These actors are international and national research centers, extension, non-government organizations (NGOs), policy-makers, local producers and user groups, and farmers. Tiwari et al. (2008) indicated that implementing a program successfully needs to be designed and fulfilled through organizations by a multi-sectoral-type community basis. It would be possible by supporting local institutions and enabling their members to manage institutions themselves (Tiwari et al. 2008). Local institutions can earn financial resources from government agencies, NGOs, and private donors (Zamani et al. 2006).

Monitoring

Prager et al. (2011) highlighted the reinforcement of monitoring via a stronger database covering soil management trends. Prager et al. (2011) indicated that the data and monitoring systems are available. However there are still challenges for:

(i) measuring the effects of farming practices on soil processes and functionalities (at least large scale);
(ii) the link of policies to specified effects (often caused by multiple factors);
(iii) assessing the policy effectiveness (most policies have more than one objective, are too general, and not locally adapted);
(iv) measuring transaction costs of policies.

Conclusion

This paper reviewed the results of published papers and reports on different aspects of water quality management of the Gharasou River. According to the review of current literature for the management of water quality, some conclusions can be outlined as follows:

1. To eliminate soil erosion in the Gharasou River Basin, some solutions are given including the conversion of rain-fed lands and other land uses located in hilly areas to forest (or orchard) or pasture and first class rangeland, prioritizing sub-basins of the Gharasou River Basin that are responsible for the highest amounts of sediment yield regarding UFR technique, prohibiting improper agricultural activities, organic farming, government investment for rangelands, and improving local industries to increase rangers' participation in RMCs.
2. Vulnerability management can improve farmers' livelihood, and the farmers' ability to deal with drought, which leads to mitigating drought impacts. It is made possible by allowing local farmers more participation in planning and implementing drought recovery management. Currently, it is evident that the farmers' vulnerability in Kermanshah province is influenced mainly by economic, socio-cultural, psychological, technical, and infrastructural factors. Policy-makers can consider these factors for vulnerability management of drought. Coping with drought should be found at the individual and the community levels. To prevent or counteract resource loss during hard times, well-developed agricultural extension systems could be taught to victims. Useful stress reduction techniques, such as efficient water use, are helpful. Water use efficiency is increased by the introduction of drought-resistant crops to farmers, conjunctive management of surface and groundwater resources, finding the best cultivation patterns, and the transference of water management responsibility to the local users.
3. To control water pollution of the Gharasou River, wastewater treatment plants, phytoremediation, filtering, and removal of nutritious elements of sewage or deviation of sewage path are the management strategies suggested.
4. Local communities such as WUAs should be considered to enhance rural communities' capacity to resolve their problems by themselves. Then, farmers can participate in a research process of sustainable management of resources, including soil, water, and rangelands in the company of researchers, extension systems, NGOs, cooperatives, and policy-makers.

Study limitations

For the Gharasou River Basin, there is no current information available about the management strategies and policies regarding the population's participation in controlling water pollution, soil conservation techniques, the effects of education on people's participation, and the role of the extension system and NGOs, which are necessary for the implementation of the suggestions made above.

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