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ORIGINAL ARTICLE

Impact of provincial water management on environment and social welfare in West of Zayanderood Basin, Iran

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Water is the important limitations of management in Zayanderood basin. Adoption and implementation of basin water management bill as provincial in the parliament in 2006. Zayanderood basin management became a dual management and increased the environmental degradation for agricultural production in the west of the basin. The aim of this study is to investigate the impact of the non-expert decision of managers on the environment and water in the west of the Zayanderud basin. So, land cover changes were investigated using Landsat images in the basin from 1993 to 2015. Then, the cost of the destruction of rangeland was estimated in this area for agricultural development. In this study, some of the indicators for measuring the economic values of ecosystems have improved compared to previous studies. Results showed that the change cover land is increasing quickly, while water scarcity of Zayanderood basin has remained in critical condition. Also, an economic value of at least US$1179.77 per hectare was delivered to people in 2015 by the rangeland and the cost of destruction rangelands was $10,247.3 per hectare over the last decade. The total cost of the destruction of rangelands was calculated around US$ 21,341,342.5 from 2008 to 2015 in this area. The result showed the impact of natural resource services destruction on person's welfare. So, proposed to the decision makers to consider the economic value of rangeland for assessment of agricultural development projects, because the projects with high social costs is not adopted in this area.
Key words: Zayanderood basin; environmental valuation; land cover changes; rangeland

Introduction

Environment services play an important role in human life. The demand for ecosystem services has surpassed demand for most commodities in the world. The environmental services are the benefits flow from environment to people. The benefits of natural resource are still underestimated because calculating the value of their indirect use is very difficult.

If natural resources are managed and protected, they present benefits to all generations. There is an expansive growth in studies on the advantages of natural resource and ecosystem functions to human welfare (Costanza et al., 1997; Daily et al., 2000; De Groot et al., 2002; Karimzadegan et al., 2007; Stenger et al., 2009; Ojea et al., 2012; Sabic et al., 2013). Even though the studies on environmental services has increased, there is no comprehensive and integrated framework for assessing the functioning of the ecosystem.

Water scarcity and destruction of natural resources are two most important environmental challenges in Zayanderood basin and proper use of water is important in the management of the basin. Many factors, including population growth, farmland development and the increase in industrial demand caused the crisis and water shortages in the region. Nowadays, the public attention to non-market benefits of natural resources, especially rangelands are increased in the Zayanderood basin. Rangeland is one of most important and most valuable national assets that can play a basic role in soil and water conservation and protein requirements of the basin if exploited correctly along with range restoration practices.

After the adoption and implementation of the provincial management of the Zayanderood basin in 2006, rangeland destruction has intensified in the west of the basin in Chaharmahal Bakhtyari province, that this change is regardless of social and environmental benefits. The main driver of rangeland destruction has been converted to farmlands and orchards in this area. Conversion of Pastures to other land uses, local household income has increased in the short term, but because of the increased runoff, flood, disorder, hydrological, erosion and finally environmental instability, their incomes will be reduced and public and national security are threatened in the long run. Ecosystem functions supply the services and goods that are necessary for life, therefore, this paper has calculated the economic value of functions in rangelands in the West of the basin.

This study had evaluated land cover/use changes of Zayanderood basin using Landsat images. Then the market and non-market functions value of pastures were estimated in the west of the Zayanderood basin and the total damage caused by the destruction of pastures was determined. And in the end, after assessing the results of this study, were presented strategies for making better use of pastures due to the limitations and problems of the region.

Zayanderood River basin

The Zayanderood basin is in the center of Iran in geographical coordinates of 50°02' to 53°24'E and 31°11’ to 33°42'N and covers a massive domain (Fig. 1).

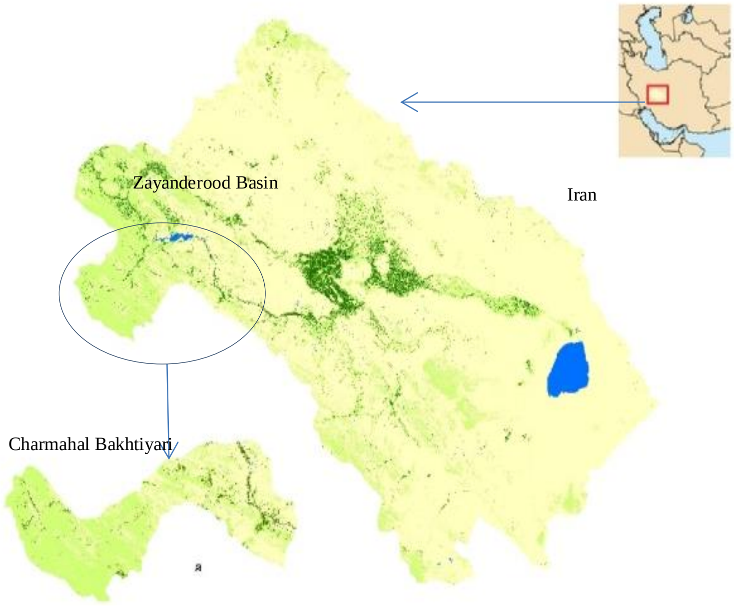


Fig. 1. Geographical extent of the Zayanderood basin and Charmaha Bakhtiyari province in the basin.

Zayanderood river is the main branch in this basin and hails from Bakhtiyari mountains (the West) to Gavkhoni pond (the East) after 359 km. The average altitude of the earth varies between 3600 to 1183 m and about milieu of 41500 km^2. Average rain is about 105 mm annually and the maximum average rain is about 1365 mm in western parts of the basin. The study area is the west of the Zayanderood basin in Charmaha Bakhtiyari province (Saman and Bon area), Iran (Fig. 1). The type of weather is cold and dry. This area receives about 320 mm of annual precipitation. The mean temperature is 12 °C annually. Almost, the landscape is lush mountainous with numerous hill and dale. The main occupations of the region's inhabitants are farming, pastoralism (traditional husbandry) and beekeeping. Sheep and goat are the dominant livestock. The most important rural activity is horticulture and especially almond production in this area.

Methodology

The needed data was collected from the forest and Rangeland Organization and Ministry of Agriculture, Ministry of Energy, USGS site and ISI Web of Science.

This survey concentrates on commodities and services on rangeland value. The services are not represented in economic markets in Iran; therefore, most of the assessments are incorrect for rangelands. The approach is divided into five parts: (i)the evaluation of land cover/use changes of Zayanderood basin using Landsat satellite images, (ii)the determination of the market value of rangeland in west of Zayanderood basin, (iii) the estimation of non-market value of rangeland in this area, (iv) the calculation of total values and the analysis of them using relevant management, (v) comparisons and future recommendations.

Land cover/use changes

The geometry correction of image data must be performed before using image processing programs and the residuals and the RMS errors between the source X, Y coordinates are determined. Atmospheric corrections are necessary for satellite images, especially in change detection analyses. The Landsat sensors capture reflected solar energy, convert these data to radiance, then rescale these data into a digital number (DN).

Then, the DN is converted to TOA Reflectance in two steps: 1) The DN is converted to radiance data by Eq. 1, 2, the radiance value is changed to TOA reflectance using Eq. 2 (Sukmono, 2017).

$$\rho\lambda' = M^{\rho} Q^{cal} + A^{\rho} \quad 1.$$

$$\rho\lambda = \rho\lambda' / \sin(\theta^{SE}) \quad 2.$$

Where:
ρλ' = TOA planetary reflectance, without improvement for the sunlight angle.
M^{ρ} = REFLECTANCE_MULT_BAND_x
A^{ρ} = REFLECTANCE_ADD_BAND_x
Q^{cal} = DN,
ρλ = TOA planetary reflectance,
θ^{SE} = SUN_ ELEVATION
The numerical indicator of Normalized Difference Vegetation Index (NDVI) has found a wide application to study vegetation at large scales (Peng et al., 2011; Fensholt and Proud, 2012; Miao et al., 2015; Tian et al., 2015). NDVI is calculated from the visible (Red band) and near-infrared (NIR band)light reflected by vegetation Eq. 3 (Dobrinescu, 2010). The NDVI values range from -1 to 1. In this study, -1 - 0 values are water, 0 - 0.1 values show bare soil and over 0.1 represent vegetation.

$$NDVI= (NIR-RED)/(NIR+RED) \qquad 3.$$

Market value of rangelands

Rangeland is the major sources of feed for livestock forage. The forage production of rangelands is a heterogeneous commodity in terms of species, the palatability and digestibility of nutrients, so to determine the amount of forage production, should be homogeneous in terms of nutritional value. The TDN index is used for the homogenization of different plant species. Total Digestible Nutrient (TDN) is the index of calculating the energy value of a feed. Also, rangelands produce medical and industrial plants that some of them are exported. There are a lot of medicinal plants in mountainous areas and valleys in the West of the basin (around 31% Of species). The growth and production of medicinal plants in rangelands can create many job opportunities. In other words, the development of drug crops due to high economic value, alongside maintaining of natural habitats, create sustainable jobs and improve living conditions in the region. In determining the value of medicinal plants in pastures, the average production per hectare of pasture and then the average market price valuation is intended.

Mon- market value of ecosystem services

The ESV analysis is based on three steps: (1) ecosystem services selection, (2) definition of the indexes and methods for economic valuations, (3) calculating the value of ecosystem per USD.

Selection of ecosystem services

The first step in the economic assessment is to identify ecosystem services related to these resources(Brenner et al., 2010). This study has been reviewed several typologies that had been developed for the valuation of ecosystem and application in integral ecological assessments such as (Costanza et al., 1997; Daily et al., 2000; De Groot et al., 2002; Karimzadegan et al., 2007; Stenger et al., 2009). Based on these studies, ecosystem functions have been selected based on the type of natural resource, available data and the objectives of assessment for different studies.
Defining the indexes and methods for economic valuations
When there are no markets for ecosystem services, we need to use indirect approaches to valuing. The valuation methods of the non-market functions of ecosystems are divided into three categories; conventional market method, implicit market method and artificial market method (Karimzadegan et al., 2007).
1. Conventional market method: this method uses market prices or shadow pricing for valuation of ecosystems.
2. Implicit market method: this method values ecosystems using implicit markets. The most important techniques are travel cost and hedonic pricing.
3.. Artificial market method: Various approaches to the evaluation of the artificial market can be used to prepare for payment or having or losing these services.
Calculating the value of ecosystem per USD unit.
The standardized unit is required to use and compare the results of studies together. In this paper, the annual consumer price index of USA was used for unit standardization. The IRR (Iran's currency) was converted into USD using the fixed exchange rate defined in 2015 by the central bank of Iran ($1 USD = 30900 IRR)

Total valuation and analysis

In this study, was calculated market and non-market values of rangelands since 2005 until 2016 (provincial management basin acted in 2005) using Eq. 4.

$$TVN = \sum_{n=-1}^{n=10} \frac{NMV}{(1+i)^n} + \sum_{n=-1}^{n=10} \frac{MV}{(1+j)^n} \qquad 4.$$

Where:
TVN is the total value of natural resource for many years per hectare, *NMV* and *MV* are respectively the annual non-market and market value of ecosystem in the current year (2015) per hectare, *i* is a social rate of return (5% in Iran) and *j* is return on investment (15% in Iran), *n* is amount of years.
The total value determined as the total costs of environmental destruction and analyzed for relevant basin management. Total damage cost of rangelands destruction calculated on Eq. 5 for the last decade in the religion.

$$TDC = \sum_{i=1}^{n} (T_i - T_1)V_i \qquad 5.$$

Where:

TDC is the total damage cost of rangelands for many years, T_i is the total area of agricultural class in the religion for ith year, T_1 is the total area of agricultural class in the religion for 1th year (2008), V_i is the annual value of ecosystem base on the current year (2015) per hectare, $i= 1,2, \ldots, n$ means from 2008 to 2015.

For use Eq 5, T_i was lost for three years (2010,2011.2012). So, applied Newton interpolation polynomial method for lost points. The general form of this method was presented as follows:

Newton interpolating polynomial method:

The Newton interpolating polynomial method is written for $n+1$ data points, $(x_0 , y_0), (x_1 , y_1), \ldots, (x_0 , y_0), (x_{n-1} , y_{n-1}), (x_n , y_n)$,as

$$f_n(x) = b_0 + b_1(x - x_0) + \ldots + b_n(x - x_0)(x - x_1)\ldots(x - x_{n-1}) \quad 6.$$

Where

$b_0= f[x_0]$

$b_1= f[x_1,x_0]$

$b_2= f[x_2, x_1, x_0]$

$\vdots$

$b_{n-1}= f[x_{n-1}, x_{n-2},\ldots, x_0]$

$b_n= f[x_n, x_{n-1},\ldots, x_0]$

where the definition of the mth divided difference is

$b_m= f[x_m,\ldots, x_0]$

$$= \frac{f[x_m,\ldots,x_0] - f[x_{m-1},\ldots,x_0]}{x_m - x_0}$$

From the above definition, it can be seen that the divided differences are calculated recursively(Steffensen, 2006).

Result and discussion

Land cover/use change images

This study aimed to evaluate land cover/use changes of Zayanderood basin and the west of the basin in Charmaha & Bkhtiyari province using Landsat 8 and 5 satellite images. Fifty images over 23 years period (1993- 2015) were compared and geometric, atmospheric corrections were applied. NDVI index was used to detect land use changes as it has been used to estimate Image classifications were done for the four land use/ cover classes i.e. forest and agriculture, rangeland, bare land, water. Four years selected as samples of all maps over the period. The result showed in Figs 2, 3.

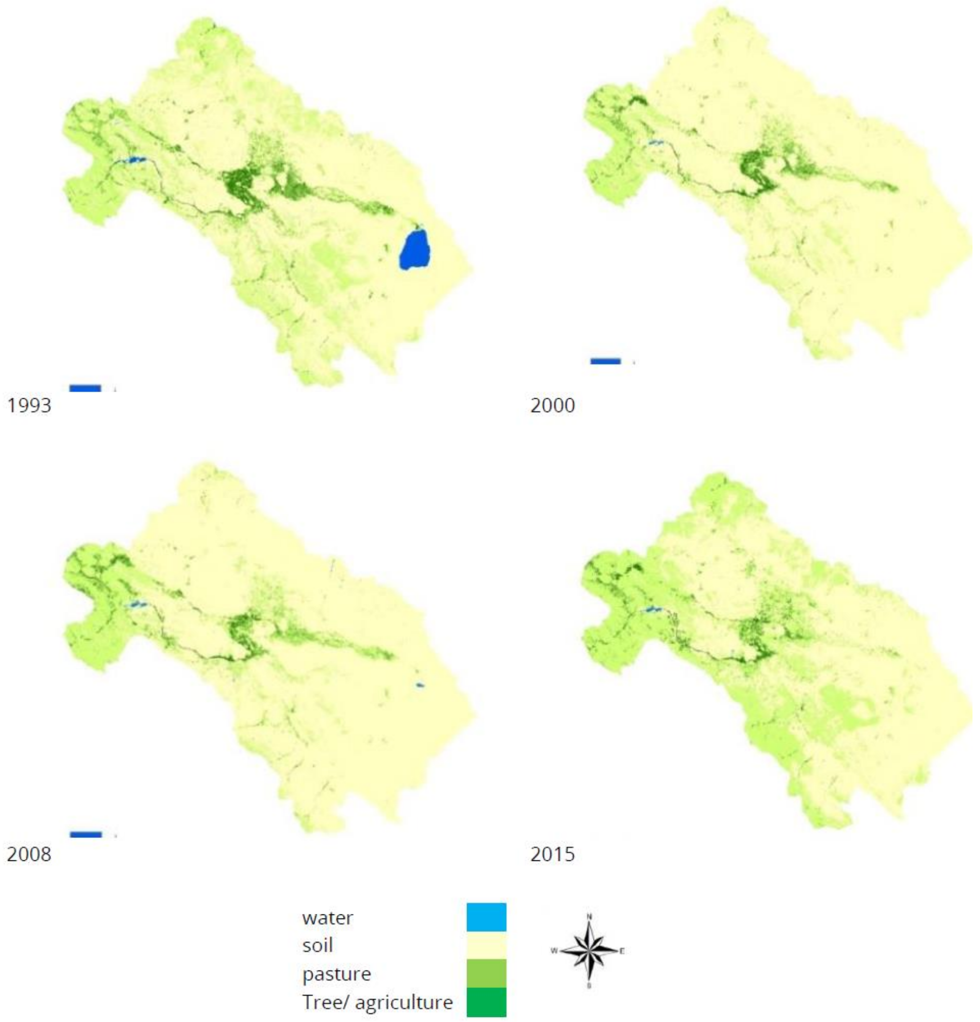


Fig. 2. Land use/change cover maps over 23-years-period in Zayanderood Basin.

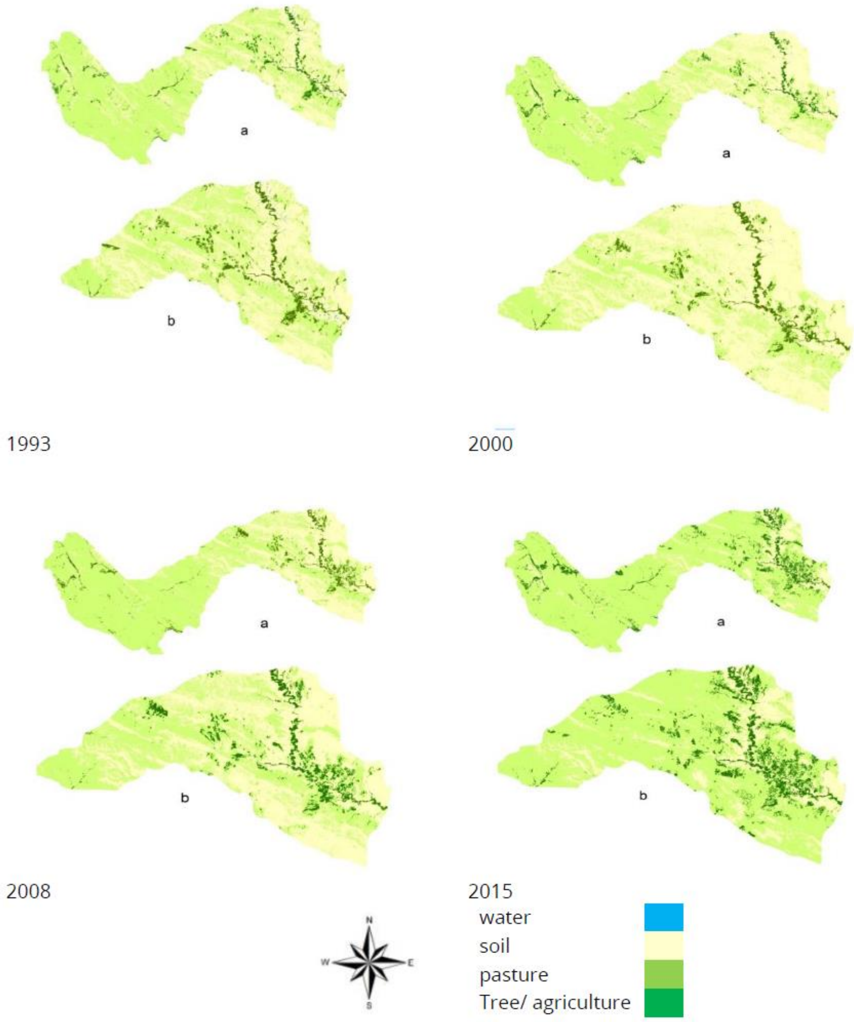
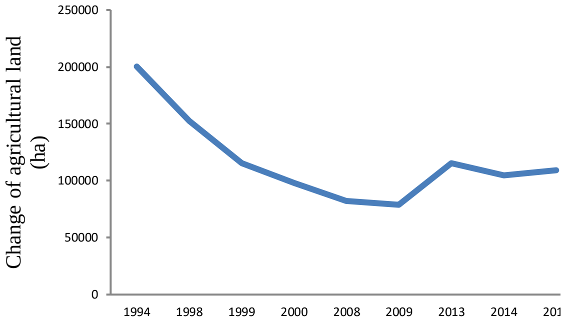


Fig. 3. Land use/change cover maps over a 23-years-period. (a) The west of the basin in Charmahal Bakhtiyari province, (b) Bon and Saman cities in the west of the basin.

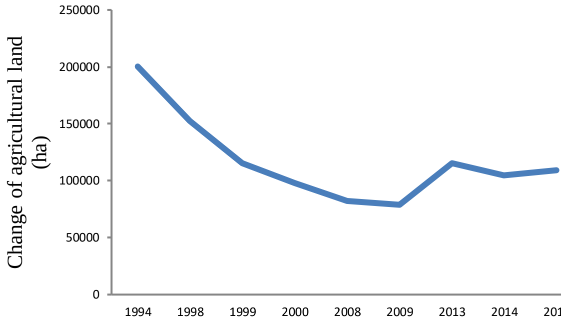
Evaluation of maps in Fig. 2 showed that Ghavkhoni wetland and Zayanderood Dam lake dramatically have been changed to bare soil and shrink from 62870.5 to 4272.6 hectares since two decades (6.7% capacity has water).
Fig. 2 and Fig. 4b, and Table 1 showed that during this period, Isfahan province agricultural lands have been decreased from 204312.5 to 109373.0 hectares in this basin (around 43% decrease), although, around 857984 hectares of this province in the basin are suitable for surface irrigation and agricultural activities (Isfahan agriculture office).

Table 1. Area of agricultural land classification for every province in Zayanderood basin (ha).

Area	1993	1994	1998	1999	2000
All Basin	211260.6	205921.6	160135.1	120908.3	104504.6
Isfahan	204312.5	200300.7	152739.5	115320.7	98078.3
Charmahal & Bakhtyari	6948.0	5620.8	7395.6	5587.6	6426.3
Bon &Saman	5090.3	4275.9	5284.7	3950.0	4062.4
Area	2008	2009	2013	2014	2015
All Basin	89888.8	86368.4	126697.8	116998.8	122351.4
Isfahan	82344.8	78861.8	115140.3	104497.8	109373.0
Charmahal & Bakhtyari	7506.6	7544.0	11557.5	12501.0	12978.3
Bon &Saman	5506.1	5199.9	7988.1	8604.8	8992.2



a



b

Fig. 4. Change of agricultural class in (a) Charmahal Bakhtiyari province, (b) isfahan province (1993–2015).

The result showed that parts of rangelands have been changed to agricultural lands rapidly in Charmahal Bakhtiyari province in the last decade compared with first decade. (Fig. 3, Fig. 4a). In this area, agricultural lands have been increased from 6948 to 12978.3 hectares;however, according to Table 2, only 5894 hectares are suitable for agricultural activities in this area.

Table 2. The suitable area for irrigation in Charmahal and Bakhtiyari province in the basin.

	Suitable area (ha)	
	Surface irrigation	Pressurized irrigation
Charmahal& Bakhtiyari	2922	5894

Market value of rangeland

Using the TDN index and in compliance with the principle of 50 percent for harvesting forage (to observe the principle of sustainable use), the average of dry matter production is estimated about 275.5 kg of dry matter weight of barley per hectare of semi-arid rangelands.

Guaranteed purchase price of barley was $0.32 per kg and the world price of barley was $237.7 per ton in 2015. According to the average price of barley (the guaranteed purchase price and the world price) and the average dry matter production, forage value is $ 55 per hectare annually.

Wholesale prices of medicinal herbs are in the price range of $3.23 to $16.18 per kg in this area, therefore the average price ($9.7 per kg) as the value of medicinal plants is considered. According to experts, the production of medicinal plants (naturally) is at least 20 kg/ha/yr. Considering the average price of medicinal plants, the value of pasture is $496.8 ha/year approximately that the production will be multiplied with the projects of medicinal plant production and value ranges will be more than the current value.

Non-market value of rangeland

In this study, determined and assessed the value of the non- market functions provided by rangeland. These functions have been selected based on the data and limitations available. Some functions have improved over previous studies. The results are as follows

Gas regulation

One of the services that ecosystems provide is gas regulation that has influence on the atmospheric composition. The most important services of the Gas regulation function are air cleaner, breathing, preventing diseases such as skin cancer etc. Iran rangeland carbon sequestration was 0.64 tons of woody plants and 0.2 tons per hectare of forage plants. In the study area, the vegetation of pasture is a mix of woody plants and forage, so the average of two types cover (0.42 ton/ha) was intended for carbon absorbed annually. The cost of carbon reduction or a tax on carbon emissions was $20 per ton (Panahi, 2005). Also, the amount of oxygen in the rangelands of Iran was averaging 0.47 per ton/ha and the oxygen production value was estimated using the price of oxygen in the industry ($20 per ton).

Water supply

Water penetration in pastures is more than agricultural land. In the study area, precipitation was 290 mm / ha in 2015 and 34% water was saved by pastures. The replacement cost method was used for economic valuation of water penetration. The economic value of water infiltration was intended based on the cost of building of artificial structures for water supply such as dams and water reservoirs (per cubic meter for water storage capacity). The annual value of saving and infiltrate water was estimated $24.49 per hectare on rangelands in the west of the basin.

Hydrological regulation and waste treatment

Several studies have demonstrated a relationship between rangeland vegetation and fresh water with good quality. Rangelands play a key role in groundwater nitrate uptake. According to Costanza et al. (1997) and CPI index in US, Economic value of adjusting the surface waters was estimated at $ 4.43 and reduce the cost of water treatment and removal of pollutants was $ 122.58 per hectare. This included improving water conditions in the river for aquaculture production.

Disturbance prevention

Flood control is one important disturbance prevention function in the rangeland. Rangelands are prevented flooding on mountain slopes. Damage cost and life losses were considered as the value of this function. The value of Rangelands in flood control and damage reduction is $ 0.27 per hectare in 2015(Pattanayak and Kramer, 2001).

Soil retention

The roots of plants play a major role in soil conservation, maintain productivity in farmland and prevention damage of wind and water erosion. In addition to soil erosion, it is difficult to penetrate water in the land without soil. This function depends on vegetation cover and the root system of ecosystems. Depending on the amount of lost elements in the soil and accumulation of sediments in dams (Edwards, 2013), using the replacement cost method, soil retention was valued at $29 (ha/year).

Nutrient cycling

The major nutrients of soils are nitrogen (N), phosphorous (P) and potassium (K) and play a necessary role in the soil fertility. Therefore, the determination of these elements in the soil of protected Rangelands compared with degraded rangelands, show Rangelands importance in the maintenance of the nutrient in ecosystems. With regards to fertilizer prices of area, ammonium phosphate and potassium sulfate, nutrient cycling function of pasture was valued at $22 per hectare in this area (Costanza *et al.*, 1997).

Soil formation

It takes about 100 to 400 years to form every centimeter of the soil. (Pimentel and Wilson, 1997). According to Edwards (2013), the average rates of soil formation are likely under 2.47 tons per hectare per year. In the study area, the amount of soil formation is 1600 kg per hectare annually so, soil formation value is $517 based on the price of fertile soil on the market.

Habitat

Rangelands create living space for wild plants variety. Wild plants supply the majority of the rangeland functions; therefore, protection of plant species is important for the provision of rangeland functions and goods. In this study, the value of habitat for a species was considered $3.5 per hectare(Stenger *et al.*, 2009) and there is around 50 species per hectare in rangelands in the west of the basin.

Pollination

Pollination is necessary for plant reproduction by insects, birds and bats therefore, it was impossible to put a price tag on this service. According to Karimzadegan (2007), annual value of this asset was determined around $18 per ha by considering the role of pollinator in increase of agricultural and garden products, livestock products and nitrogen fixation in the area.

Ecotourism

Eco-tourism is responsible travel to nature that protects natural resources and improves the condition of residents. It can make market for local goods and services.

Eco-tourism is committed for sustaining and preserving the variety of natural resources and cultural environments. Using of estimating on the economic value of eco-tourism methods for rangelands in this area, needed sample visitors. In this study, was skipped the value of eco-tourism in the region because it was in the other park and tourist area directions and there were no visitors for answering questions, Although, this area is important in terms of the natural landscape.

Value of rangeland

By using the method proposed by Costanza et al. (1997) and others, this paper calculated value of rangeland services in the west of Zayanderood basin. As Table 3, the marginal economic value of rangeland is US$ 1179.77 annually.

Table 3. Value of ecosystem services provided by rangeland in the west of the Zayanderood basin (US$/ha/yr in 2015)

Forage value	Medicinal plants	Gas regulation	Pollination	Water supply	Hydrological regulation	Waste treatment	Total of non-market function	Total
55	194	18	18	24.49	122.58	4.43		
Disturbance prevention	Soil retention	Nutrient cycling	Soil formation	Habitat	Ecotourism			
0.2	29	22	517	275	-		930.77	1179.77

Fig. 5 shows the contribution of ecosystems in rangelands in the west of Zayanderood basin. Soil formation has the highest percentage of distribution (50.29%) in the area and Habitat and Medicinal plants, respectively, were the next categories.

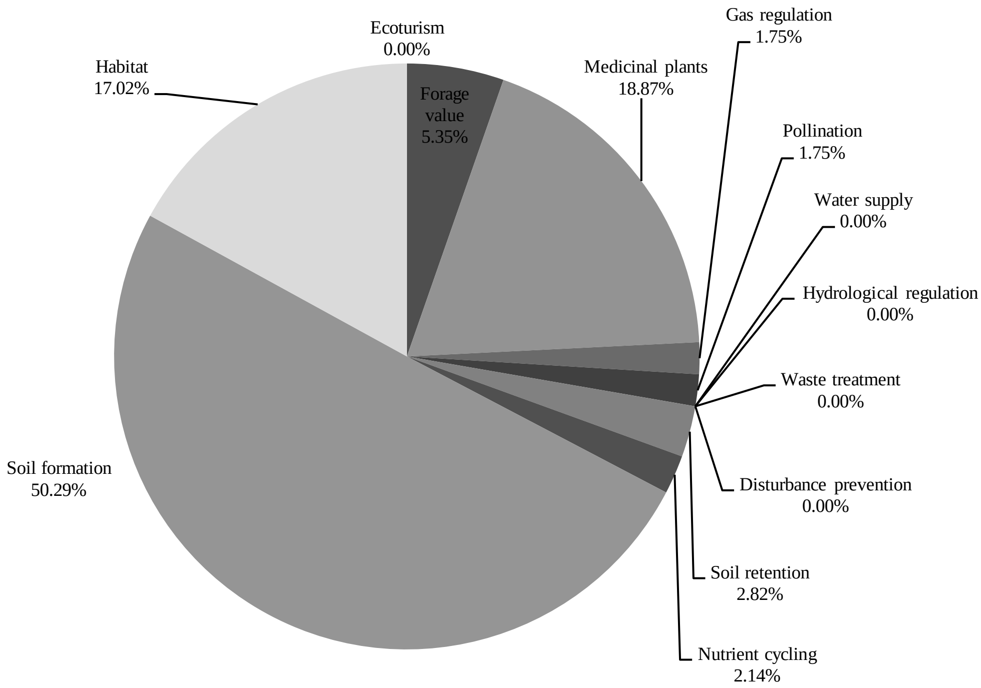


Fig. 5. Contribution to annual flow value based on the ecosystem service type in rangeland of the west of Zayanderood basin.

Comparisons

The results of the current study were compared with two others in Table 4.

Table 4. Comparison of studies on the non-market value of rangeland. Data standardized in 2015.

	Area (ha×10^6)	Pop (pop×10^6)	Value (USD/ha per year)
World[a]	51.63	6.46	342.30
Catalan[b]	0.90	4.30	288.0
West of Zayanderood	0.20	0.07	930.70

[a]World data from Costanza et al. (1997), [b]Catalan data from Bernner et al. (2010)

The comparison shows, the Zayanderood assessment achieved a higher value than the other studies ($ 930.7 USD/hr. · year compared with $342.3 USD/hr. · year and $288 USD/hr. · year, respectively). The differences between values can be explained due to the cover types, the nature areas, land scale and the number and type of functions in these studies.

The result of value in Zayanderood was higher than that reported by Costanza et al. (1997) based on many important advances. This study was conducted 18 years after the global study. During this period, many studies have been carried out on ecosystem value estimation, which has improved the valuation indices and the number of available online data has increased.

However, the rate of pastures by the Department of Natural Resources is much lower than the results obtained in this study ($192.5 - $412.6 per hectare); therefore, evaluation of projects based on economic criteria has not been done properly.

Total damage cost

Change of pastures to the orchards and agriculture, has been increasing rapidly in the study area from 2006. Table 4 shows the damage cost of destruction rangelands over the last decade and forecast of damage in 2016 using Eq. 4. The total damage of pastures is $10247.3 per hectare ($8523.8 for non-market functions and $1723.5 for market functions per hectare).

Furthermore, has been spent around $338 per hectare to implement water supply projects to develop agriculture in the area. Three years were lost for calculate of the total damage cost. So, these points were estimated based on Newton interpolation polynomial method (Eq. 6). The polynomial was got as follows:

$$P(x) = 7506.6 + 37.4\,(x-1) + 193.2\,(x-1)(x-2) - 60.9\,(x-1)(x-2)(x-6) \qquad 7.$$

Hence, T_{2010} = 7976.4, T_{2011} = 8913.9 and T_{2012} = 10229.2.

Therefore, according to Eq. 5, the total costs of destruction of rangelands were estimated around US$ 21341342.5 from 2008 to 2015 in the west of the basin.

In this study, the destruction of rangelands costs estimated were only to prepare to start agricultural activities, While, there are good agricultural lands in the east of the basin that unused due to lack of water in this area. The results show that the technical and economic evaluation has not been considered in the allocation of water in the basin and more decisions are based on ethnic and political thinking and no economic justification.

Conclusions

This study created a set of criteria for assessing the value of ecosystem services using a value transfer approach for the west of the Zayanderood basin. Results show that an economic value of at least US$1179.77 per hectare was delivered to people in 2015 by the rangeland. The analysis revealed that Soil information and Medical plants provided 69% of the total ecosystem service value in rangeland. As rangeland services will become scarce in the future, their value is expected to increase. These results confirm the relative significance of non-market services of rangelands and show the influence of their demolition on the welfare of local and global people.

The total cost of the destruction of rangelands was calculated around 21,341,342.5 USD from 2008 to 2015 in the West of the basin. This cost is to prepare to start agricultural activities in the area While crop lands in the east of the basin are waiting for water to cultivate.

Table 5. Environmental damage caused by the destruction of grassland in the West River, 2006–2016

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	**Sum**
non-market functions	600	630	661.5	694.6	729.3	765.7	804	844.2	886.4	930.8	977.3	**8523.8**
market functions	70.8	81.4	93.6	107.6	123.8	142.4	163.7	188.3	216.5	249	286.4	**1723.5**
Total function	670.8	711.4	755.1	802.2	853.1	908.1	967.8	1032.5	1103	1179.8	1263.7	**10247.3**

This estimate can be used in rangelands and area with similar climates, or even in inaccessible regions. The results of this research can help managers and planners to make the right decision about the use of natural resource, especially rangelands considering by general welfare. Also, it increases the knowledge of people about the high economic value of rangelands and importance of ecosystem in their lives.

We should emphasize that this study is just the starting point for calculating the damage of environmental in the Zayanderood basin and more researches are needed for some of the special aspects. In the future, there is a need for more major valuation studies of passive use values of rangelands and studies of prices for rangeland goods in these emerging markets.

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