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A Pricing Model for Value of Gas Regulation Function of Natural Resources Ecosystems (Case Study: Sheikh Musa Rangeland, Mazandaran Province, Iran)

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Abstract. Rangeland ecosystems provide a wide range of services such as gas regulation function whose economic value has not been understood. The present study aimed to estimate the economic value of CO_2 absorption and oxygen generation services using unit price in Sheikh Musa Rangeland, Mazandaran Province, Iran. In the study area, clipping and weight and photosynthesis methods were applied to estimate dry matter production, CO_2 absorption, and oxygen production. Also, Shadow price, Replacement cost, and Social cost methods priced the economic value of gas regulation function differently. Finally, their means were compared and their geometric mean was used as the unit price; then, the economic value of the function was estimated in 2016. Results showed that Sheikh Musa Rangeland ecosystem annually produces 2081.4 t dry matters and 2454 t oxygen and absorbs 7294.15 t CO_2. Given the estimated price, the value of CO_2 absorption function was found to be 7264.6 million IRR and the economic value of oxygen production was calculated as 3,852 million IRR per year. In overall, the economic value of Sheikh Musa ecosystem was estimated as 11117.4 million IRR (318364 US $) per year and 1.06 million IRR per ha. Given the valuation that shows the minimum value of Sheikh Musa ecosystem and high importance of its gas regulation function, it is recommended to conduct further studies on pricing models for Rangeland ecosystems and to apply environmental management practices for the sake of Rangeland and local health.

Key words: Economic valuation, Oxygen generation, Carbon sequestration, Sheikh Musa

Introduction

Economic growth makes up the core of planning in most countries, especially in developing countries. Unfortunately, economic growth has had disastrous consequences, particularly to environment (Fatahi *et al*., 2015) because environment is the substrate for most economic activities and indeed, environment and economic growth are interdependent in their most rudiment forms (Sharzehi & Haghani, 2009). Undoubtedly, environment conservation and the control of environment pollutants are the main ways for holistic sustainable development. Given the reliance of mankind survival to natural resources, our fate is tied to the conservation and optimal exploitation of these resources. Environmental resources make an asset to which our survival is bound. Thus, it is imperative to enact the designated laws and managerial practices both at national and international levels; otherwise, we are destined to witness catastrophic disasters. Most our physical requirements are supplied from natural resources. Natural resources are a part of production factors which play a key role in manufacturing and services and consequently, in economic growth along with labor and capital factors (Ghorbani & Firuz Zare, 2010). Renewable natural resources make the backbone of socio-economic survival of a community so that development would not be made possible if it is not supported by natural resources. Even the improvement of agricultural production requires the support of renewable resources turned into agroforestry[1] as the integrated form of agriculture and forestry. Nonetheless, these resources are renewed with a certain rate over a certain time span. If their exploitation rates exceed their renewing rates, they will start depleting and will be rendered useless (Fatahi, 2014).

An overview of CO_2 emission in the world and in Iran

Greenhouse Gas (GNG) emissions are rooted in fossil fuels in the first place and in land use changes as well as their net absorption into oceans in the second place (IPCC, 2014). CO_2 is the most important GNG and nearly 60% of greenhouse effects arisen from human activities are related to the emission of CO_2 (Baniasadi & Zare Mehrjordi, 2016). Atmospheric CO_2 content was estimated at 400.87 ppm in September 2016 whereas it was 397.31 and 378.61 ppm in September 2015 and 2006, respectively (NOAA, ESRL, Maunala Observatory, 2016)[2] and 280 ppm in pre-industrialization era. The concentration of CO_2 alone has increased at about 40% as compared to its pre-industrialization concentration (IPCC, 2016). Table 1 summarizes the emission rate and the share of 10 top CO_2 producing countries in the world.

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[1] It is a system of land use in which animals or crops are integrated with trees or shrubs (for wood production) (Smith *et al*., 2012). In this production system, trees improve soil carbon fixation.

[2] Figures are provided by different international organizations and entities and have been measured by different methods. So, there are inconsistencies in figures.

Table 1. The emission rate and share of top 10 CO_2 producing countries in the world

Rank	Country	Carbon Dioxide Production Per Capita (Million ton)	%
1	China	10975.5	25.36
2	USA	6235.1	14.40
3	European Union	4399.1	10.16
4	India	3013.7	6.96
5	Russia	2322.2	5.36
6	Japan	1344.5	3.10
7	Brazil	1012.5	2.33
8	Indonesia	760.8	1.75
9	Mexico	723.8	1.67
10	Iran	715.0	1.65
Total		31502.2	72.28
Total world production		43286.11	100

Source: World Health Organization (2014)

According to Table 1, Iran is in the tenth rank of the highest CO_2 emission rate, which is very devastating for a country with much weaker economy than the other countries of the top ten list, especially given the fact that it is mostly covered with deserts and is deprived of a high green ecosystem percentage[3].

Statistics show that CO_2 rate has sharply increased in a long time, but its growing rate has decelerated in recent years thanks to the development of renewable energies so that according to International Energy Agency (IEA)'s report published in April 2016, the rate of CO_2 emission from energy sector as the main sector responsible for GNG emission was constant for the second consecutive year. However, most aspects of climate change and the related impacts will go on for centuries (even if GNG emission by human activities is stopped). Climate changes pose a threat to sustainable development. Thus, it is imperative to care about air pollution. Iran's rank in Environmental Performance Index (EPI)[4] was 114, 83 and 105 out of 132, 178 and 180 countries in 2012, 2014 and 2016, respectively (EPI, 2016). Accordingly, Iran's EPI was changed by +15.46% (based on ±100) in 2016 vs. 10 years age.

According to EPI (2016), Iran was ranked the 97th in climate changes and energy sub-index among 180 countries above Egypt, Turkey, and Saudi Arabia in 2016 while it was ranked the 100th among 178 countries in 2014. This sub-index reflects the growing trend of carbon and GNG emission in Iran. Thus, according to EPI, environment of Iran is not in a good condition as compared to the past, emphasizing the need for addressing the valuation of forests, rangelands and in total, whole natural ecosystem from economic, social and cultural perspectives.

Rangelands and valuation of natural ecosystems

Rangelands form the most extensive land ecosystems providing human communities with products and services. The area of Rangelands in Iran has 84.8 million ha. Per capita Rangeland is now about 1.06 ha in Iran (Frwo[5], 2008; Research findings). Some major roles that natural ecosystems like rangelands have to play are to store energy as carbon through carbon sequestration, to supply oxygen and to use them in photosynthesis. Carbon resides in soil for a long time by uptake and storage resulting in its reduction in atmosphere (Siwar *et al.*, 2016; Lal, 2004). In addition to reducing the atmospheric concentration of GHGs, Rangeland and forest ecosystems improve soil organic matters by carbon sequestration and its storage in soil and help structural stability, water retention capacity, soil nutrients availability, and the creation of a

[3] It should be noted that the per capita emission rate of GNG is 8.7 t person^{-1} yr^{-1} in Iran.

[4] EPI is prepared and released by Yale Center for Environmental Law and Policy and Center for International Earth Science Information Network, Colombia University in collaboration with the World Economic Forum every two years.

[5] Forests, Range, and Watershed Management Organization of Iran (FRWO).

proper medium for the growth of soil organisms (Lal, 2004). Carbon sequestration is also economically valuable due to biomass production and can be considered as an extra benefit of the rehabilitation of deteriorated lands and an important ecosystem service in the world (Abdi *et al.*, 2009). Given the growing concerns for global warming, Rangelands can play an essential role in regulating the temperature of Earth by carbon sequestration and oxygen generation on one hand and the absorption of GNGs, especially CO_2 on the other hand.

Today, there is a widespread consensus that the present status of the deterioration of environmental resources and pollution is associated with the lack of market for ecological goods and services (Stapleton and Garrod, 2008). On the other hand, optimum allocation of resources requires the estimation of actual value of ecosystem performance and services and the development of mechanisms for grasping their economic value (Mackenzie, 2012; Mobarghai *et al.*, 2009). In fact, valuation of ecosystem services is not by itself a goal; rather, it is a decision support tool to help us make sound decisions for environment (Mobarghai *et al.*, 2009). Valuation of natural ecosystems should not be mistaken with privatization. Indeed, valuation aims to estimate the value of natural ecosystem services by various methods and to express it in monetary units (Fatahi *et al.*, 2016). Fig. 1 displays the interactions between natural, social, human and infrastructural capitals for the health of mankind.

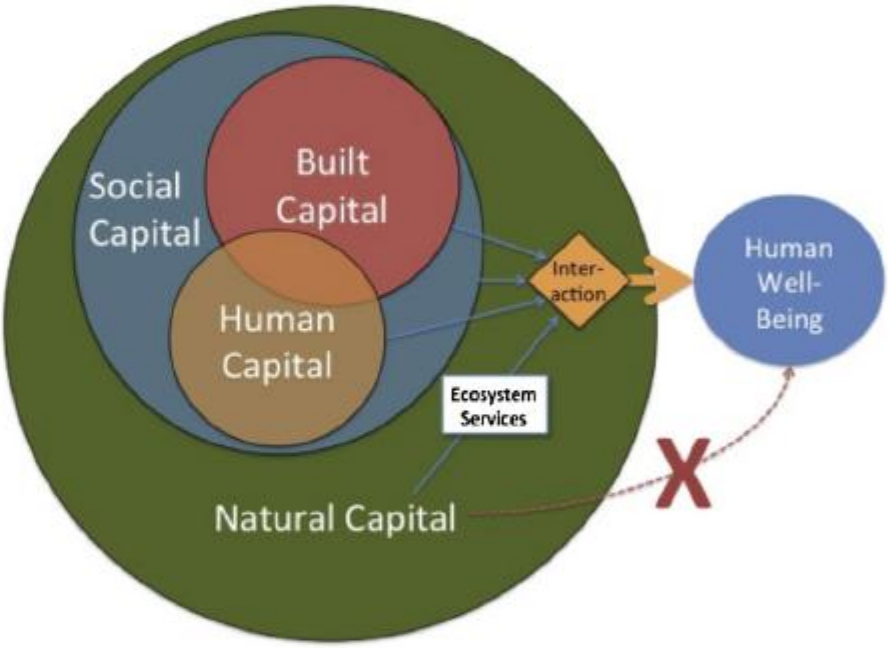

Fig. 1. Interactions between social and natural capitals (Costanza *et al.*, 2014)

According to Fig. 1, most ecosystem services are public goods and/or public assets (natural capital). It means that there is no privatization and conventional market for them. Additionally, the non-market value estimated for ecosystem services is mainly related to used and or non-used values instead of money exchange.

CO_2 uptake and oxygen supply in forests, rangelands, meadows and agricultural lands have been subjected to extensive studies. In Iran, numerous studies have been carried out on carbon fixation and oxygen generation by different ecosystems (e.g. Abdi *et al.*, 2009; Mahmoudi Taleghani *et al.*, 2007; Panahi *et al.*, 2011).

Given the importance of economic valuation of the functions of natural ecosystems, especially its gas regulation function, many attempts have been made for it in Iran and other countries. Tables 2 and 3 summarize some of them.

Table 2. A brief look at studies on carbon sequestration valuation

Reference	Methodology	Study site	The value obtained
Yeganeh *et al.*, 2015	Shadow Value	Taham watershed Rangeland type	170 thousand IRR/ha
Gren, 2015	Replacement cost	Stockholm forests as well as nutrients	307 krones
Costanza *et al.*, 2014	Replacement cost Benefits transfer Avoided cost	All forests of the world Tropical jungles Temperature	\$3800/ha \$5382/ha \$3137/ha
Costanza *et al.*, 2014	Replacement cost	Rangelands and grasslands	\$4166/ha
Badehyan *et al.*, 2015	Avoided loss costs	Inbred and mixed beech landraces of Kheirud Forests of Nowshahr	9.5 million IRR/ha for beech inbred landrace and 8.3 million IRR/ha for beech mixed landrace
Aertsens et al., 2012	Avoided cost	Agricultural lands in Europe	€282 per ha
Zarandian *et al.*, 2012	Photosynthesis	Conserved Rangeland ecosystem of Arasbaran	42.77 million IRR for whole ecosystem
Varamesh *et al.*, 2011	In vitro method	Acacia and rowan landraces in Chitgar Forest Park of Tehran	\$20 million for acacia and \$2.5 million for rowan landrace
Vincent *et al.*, 1993	Shadow value (carbon tax)	Forests of Malaysia	\$500-800
Guo *et al.*, 2001	Replacement cost	Forests of China	\$33.6 per metric ton

Source: Research findings

Table 3. A brief look at studies on oxygen generation valuation

Reference	Methodology	Study site	The value obtained
Yeganeh *et al.*, 2015	Shadow value	Taham watershed Rangeland type	781.3 thousand IRR/ha
Zarandian *et al.*, 2012	Photosynthesis	Conserved Rangeland ecosystem of Arasbaran	2.30 million IRR per whole ecosystem
Dehghani, 2012	Replacement cost	Forestations of Isfahan Steel Company	117 million IRR per whole region
Guo *et al.*, 2001	Replacement cost	China	\$52/ha

Source: Research findings

As it is evident in Tables 2 and 3, the variation ranges of both functions – carbon fixation and oxygen supply– differ greatly. An estimation on the basis of several carbon valuation studies showed that carbon valuation varies in the range of 2-500 \$ t^{-1} C (Badehyan *et al.*, 2015). These variations are usually related to the inconsistencies in inflation rate, discount rate for each country, methodology, and study time and place.

Few studies have aimed to estimate the economic value of gas regulation service of Rangeland ecosystems in Iran. It is imperative to give a specific attention to this function of Rangelands given the emphasis on the adoption of sustainable rangeland management practices, the reduction of GNG emissions, and the diversification of economic opportunities. The studies in recent years in Iran have mostly focused on forest ecosystems and have less worked on Rangelands. For example, Salehi and Molaei (2008) estimated the economic value of gas regulation function as 579788 IRR ha^{-1} in Arasbaran forest, Iran. In another study by Mobarghai *et al.* (2009) on carbon sequestration function in a part of Caspian forests of Mazandaran, it was valued as 3.93 million IRR ha^{-1}. In a study on oak forests, Asgari (2013) estimated the value of gas regulation function of oak forest as to be 2.5 million IRR ha^{-1} per year. Using replacement cost and spatial distribution of CO_2, Morovat *et al.* (2012) found the spatial value of CO_2 absorption by Baghan and Chanaran forests of Marivan to be 1.5 million

IRR ha^{-1}. The present study used photosynthesis and respiration equation and empirical measurement to estimate carbon sequestration and oxygen generation and used three methods – shadow value, replacement cost, and social cost– for the valuation of the functions.

Materials and Methods

Study area

With an area of 2375640 ha (23,756.4 km^2), Mazandaran Province composes 2.46% of total area of Iran. The natural resources of this province are divided into eastern segment (Sari) and western segment (Nowshahr). The natural resources of Babol are a part of eastern segment (Sari). The Rangeland ecosystem of Sheikh Musa is 70 km south of Babol city between the latitudes of 36°09'21" and 36°06'10" N and the longitudes of 52°40'34" and 52°30'52" E. It has an area of 10407 ha (104.07 km^2) including 87% of the Sajjadrud watershed, 71% of the Rangelands of Babol city, 2.68% of eastern Rangelands of the province (Sari segment), and 1.8% of the Rangelands of Mazandaran Province. According to administrative divisions, it is located in Firuzjah rural district, Eastern Bandpey- Sharqi district, Babol county, Mazandaran Province. Its main population center is Galugah. This district has an altitude of 2500 m (Fig. 2).

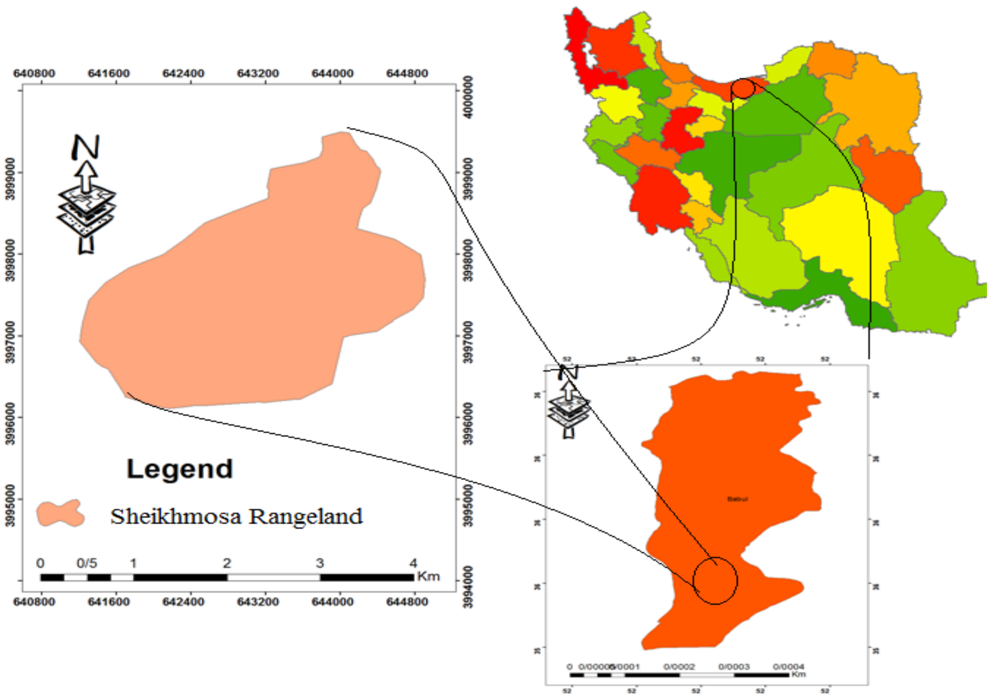

Fig. 2. The map of study site in Mazandaran Province and Iran

Methodology

The present study first quantifies the amount CO_2 absorbed and the amount of oxygen generated by Sheikh Musa Rangeland and then, deals with how to value its regulatory services.

Broadly talking, there are three methods to estimate the amount of CO_2 absorbed and the amount of oxygen generated by Rangeland ecosystems. These methods are based on the equation of photosynthesis and respiration, empirical measurements, and mathematical models (Li *et al.*, 2006; Xue and Tisdell, 2001). The present study applies empirical measurements and photosynthesis. When green parts photosynthesize, the plant cover absorbs solar radiation and coverts inorganic compounds like water and CO_2 into organic compounds. This process is one of the most important functions of plants and produces raw organic matter and energy for human consumption. The amount of absorbed CO_2 and generated oxygen can be quantified if we have the initial net production amount of the Rangeland. According to the photosynthesis equation, a plant produces 162 g amylase or plant dry matter per 264 g absorbed CO_2 (Marvi Mohajer, 2006). Therefore, a Rangeland ecosystem fixes 1.64 kg CO_2 per kg produced dry matter. Thus, the amount of absorbed CO_2 can be estimated by precise calculation of the total production rate of a Rangeland. Photosynthesis reaction is shown in Equation (1) (Barkhordar, 2014).

$$6Co_2(264g) + 6H_2o(108g) \rightarrow (Glucose)C_6H_{12}O_6(180g) + 6O_2(193g) \rightarrow Amylase\ (polysaccharide)\ (162g) \quad (1)$$

Equation (1) is used to estimate the quantity of supplied oxygen so that a plant can release 193 g oxygen as it produces 162 g dry matter. In other words, 1.2 t oxygen is released as per the production of 1 t dry matter.[6] This quantity is for coverage that is in its optimum conditions. For the coverage conditions in Iran, the figure of 191 g oxygen per 162 g produced dry matter should be used (Yeganeh *et al.*, 2015).

We need to calculate the per annum initial net production (per annum dry matter produced) of Sheikh Musa ecosystem in order to estimate its stored CO_2 and released oxygen. Total dry matter of a rangeland can be quantified by different methods, among which clipping and weighing, theoretical estimation, and double sampling are the most widely used methods (Rabiei, 2011). Since clipping and weighing method yields more precise results than the other methods (Baghestani Meybodi, 2008), it was used in the present study for which 1×1 m^2 plots were considered. Small square plots were considered to have dense plant cover. The more the number of plots and the smaller their size is, the higher the precision of measurements is (Zare Chahouki *et al.*, 2013). The sampling site was selected by simple randomization method (Deputy of Rangelands and Watershed Office of Babol County, 2016). In clipping and weighing method, the plants are cut with respect to their vegetative form and then, they are placed in specific paper pockets. So, total dry matter production of Sheikh Musa Rangeland was calculated. Following the estimation of carbon sequestration and oxygen release rates, the economic value was estimated for gas regulating function of the Rangeland ecosystem.

[6] Photosynthesizing organisms include terrestrial plants, oceanic phytoplankton and blue-green bacteria, which convert CO_2 and water into sugar and oxygen.

Results and Discussion

Quantification of CO_2 production

Clipping and weighing method estimated the dry matter production rate at 2081.4 t in Sheikh Musa Rangeland. Accordingly, Equation (1) shows that 3391.91 t CO_2 per year is absorbed and stored in plant tissues by the production of 2081.4 t dry matter. This is the amount of CO_2 absorbed into plant aerial parts whilst an amount of CO_2 is also stored in subsoil parts, soil and litter. Soil contains about 75% of carbon pool in soil, which is three times as great as the amount carbon stored in living plants and animals. Thus, it plays a crucial role in safeguarding the balance of global carbon cycle (ESA, 2000). The amount of carbon absorbed by subsoil parts is 18-22% of carbon absorbed by aerial parts and that absorbed by litter is 5% of carbon absorbed by aerial parts (FAO, 2002; Abdi *et al.*, 2008; Arabzadeh, 2012). The quantity of carbon absorbed into soil is considered to be 1 t ha^{-1} for forests (FAO, 2002) and 0.1-0.3 t ha^{-1} yr^{-1} for Rangelands (Lal, 2010; Arabzadeh, 2012). It should be remembered that since Rangelands in Iran are not in their optimum conditions, this figure is assumed to be 18 for subsoil organs and 0.3 for soil.[7] Therefore, the amount of CO_2 absorbed by aerial organs, litter and soil would be 610.54, 169.60, and 3122.1 t yr^{-1}, respectively. Consequently, total CO_2 absorbed by Sheikh Musa Rangeland ecosystem, which is the sum of CO_2 absorbed by aerial organs, subsoil organs, litter and soil, is 7294.15 t and 0.7 t ha^{-1} yr^{-1}, respectively. Panahi (2006), Dehghani (2012), Mobarghai *et al.* (2009), Abbasifar (2008), Salehi and Molaei (2010), and Zarandian *et al.* (2012) used the same method to quantify CO_2 absorbed by forest and Rangeland ecosystems.

Hence, Sheikh Musa Rangeland that annually produces 2081.4 t dry matter supplies 0.23 t ha^{-1} yr^{-1} oxygen which amounts to 22454 t oxygen. Yeganeh *et al.* (2015) estimated the amount of oxygen supply in Taham watershed at 1.56 t ha^{-1} and Zarandian *et al.* (2012) reported it as to be 0.38 t ha^{-1} for Arasbaran Rangelands. Given the fact that the human demand for oxygen is 250-300 kg $person^{-1}$ yr^{-1} (Sadr Nuri, 1992), each hectare of Sheikh Musa Rangeland can supply annual oxygen demand of 0.77-0.92 people. Thus, this ecosystem can meet oxygen demand of 8180-9816 people per year. According to the census of 2011, Firuzjah rural district is composed of 190 villages that are home to 3172 people. Then, Sheikh Musa Rangeland can produce the amount of oxygen that is twice as great as the demand of the present population of Firuzjah rural district.

Estimation of gas regulating value of Sheikh Musa rangeland

Estimation of CO_2 value

Different researchers and organizations around the world have considered different prices for the value of carbon and CO_2. For example, Fankhauser (1994) determined average carbon absorption price as $25.3 per metric ton for the 1991-2030 period. Zarandian *et al.* (2012), Yeganeh *et al.* (2015), Kumari (1995), Amirnejad (2005), Mobarghai *at al.* (2009) (on the basis of IPCC prices), Tol (2007), Karimzadegan (2011) and Vincent *et al.* (1993) assumed the prices of $23, $25.3, $14, $27.9, $63.3, $23, $100, and $8.55-60.09 per metric ton of carbon and CO_2, respectively. The recent studies in Iran have mostly tended to use the prices by IPCC because IPCC states CO_2 price on the basis of the cost of its fixation (absorption, transfer, storage and control) in oceans and lands. However, they can be criticized that the price of $63.3 does not include the full range of the costs of storage (control) process associated with artificial CO_2 sequestration as well as the cost of its compounding with minerals. Thus, the functions are undervalued. The full cost (in terms of control, absorption, transfer and storage) considered in the present study is shown in Table 4.

7. The ratio of 0.27 for CO_2

Table 4. The cost of CO_2 control, absorption, transfer, and storage (IPCC, 2005)

Process type	Performance type	Cost ($/t)	Mean ($/t)	Process mean ($/t)
Absorption	Absorption from coal, gas, and power plants Absorption from production plants of ammonia, hydrogen and other gases Absorption from other natural resources	15-75 5-55 25-115	45 30 70	48.3
Transfer	Transfer to storage phase	1-8	4.5	4.5
Storage	Storage in land Storage in ocean Combination with minerals Control on storage in land	0.5-8 5-30 50-100 0.1-0.3	4.25 17.5 75 0.2	28.23
Total cost of all processes				81.03

Thus, the real figure in triple CO_2 process is $81.03 per metric ton.[8] In addition, some other studies have focused on the social cost of carbon. For example, Brainard *et al.* (2009), Nordhaus (2011) and Stavins and Richards (2005) considered $10, $44, and $70 per metric ton of carbon, respectively. In a review of 103 studies, Tol (2005) observed various estimations ranging from $5 to $104 per metric ton. He concluded that carbon had a social cost of over $50. In another study, he reviewed 232 studies and estimated mean social cost of CO_2 at €35 ($33) per metric ton with 1% discount rate (Tol, 2008). According to Luckow *et al.* (2015) study that was collaborated with Cambridge University, the mean predicted price of CO_2 was estimated at $20, $35, and $88 per metric ton for 2020, 2030, and 2050, respectively. The US Congress sanctioned carbon price as $26 per metric ton for 2014 and $38 for 2015. French parliament sanctioned $34 for 2017 (IPPC, 2016). Social value of carbon (CO_2) can be displayed as the graph in Fig. 3 by micro-economics (Gren, 2015) (Fig. 3).

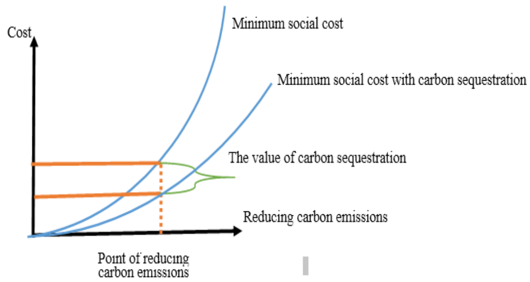

Fig. 3. Social value of carbon sequestration

In the present study, we reviewed a lot of researches by practitioners and organizations around the world. Our review implies the uncertainty in the estimations of different studies because the adoption of a single, globally accepted figure requires complicated international negotiations. Thus, we can hardly formulate a proper figure for CO_2.[9] Most studies in Iran have valued CO_2 by shadow price and replacement cost methods, but the studies in other countries have also used social cost method. So, we applied all three methods of shadow price, replacement cost, and social cost. Table 5 summarizes the valuation of CO_2 function of Sheikh Musa Rangeland ecosystem estimated by various methods.

[9]. Assuming constant price of dollar throughout the world.

[9]. REFERENCE in *Ecosystem Services* give the figure $100 per metric ton of CO_2 which does not seem exaggerated in today's perspectives.

Table 5. The valuation of CO_2 sequestration function of Sheikh Musa Rangeland

The methods used	Sources used	Price (US $/ton)	The entire rangeland functional value (us $)	Value in million riyals	Functional value per hectare (riyal)
Carbon tax	Fankhauser, 1994	25.3	184542	5864	563503
Carbon tax (The ratio of carbon dioxide: 0.27)	Fankhauser, 1994	6.83	49819.04	1583.14	152123.5
Replacement Cost (RC)	IPCC, 2005	81.03	591045	18782	1804769
Social Cost (SC)	Bateman *et al.*, 2013	29.22	213135.06	6773	650812.5
	Tol, 2008	33.00	240707	7649	735004
	Nordhaus, 2011	44.00	320942.6	10198	980006
	Tol, 2005	50.00	364707.5	11589	1113643

Source: Research findings

According to Table 5, the lowest CO_2 function value of Sheikh Musa Rangeland was found by carbon shadow price as to be 1,583.14 million IRR whilst the highest one (18,782 million IRR) was estimated by CO_2 replacement cost. Consequently, shadow price gave lower value to CO_2 function and replacement cost method gave higher value. Among different averages, geometric mean is closer to fact because it considers the numbers in terms of their share. Finally, the CO_2 absorption function of Sheikh Musa Rangeland was valued by geometric mean.

Estimation of oxygen generation value

The value of oxygen generated by Sheikh Musa Rangeland was estimated by replacement cost as the product of industrial and medical oxygen production cost in the quantity of oxygen produced by Sheikh Musa Rangeland. As it was mentioned, whole ecosystem of Sheikh Musa Rangeland produces 2454 t yr^{-1} oxygen. We assumed the cost of industrial and medical oxygen production as to be 1,570,000 IRR.

Table 6 presents the annual value of gas regulation function in terms of the price given for Sheikh Musa Rangeland ecosystem.

Table 6. Estimation of the value of gas regulation by Sheikh Musa Rangeland ecosystem

Function	The offered price (us $)	The Total amount function (tons per year)	The total value (million Riyals in the year)	Function values per hectare (tons per year)	Value ha (Riyal per year)
Absorb carbon dioxide	27.03	7294.15	7264.6	0.7	698056.6
Oxygen supply	Market value 1570000	2454	3852	0.23	370210.43
Gas Adjustment	-		11117.4	1068267.03	

Source: Research findings

Conclusions and recommendations

We estimated the economic value of gas regulation function of Sheikh Musa Rangeland ecosystem as one of the most important functions of this Rangeland. So, we first quantified CO_2 and oxygen by photosynthesis method and clipping and weighing method. Then, different prices were examined by three methods of shadow price, replacement cost and social cost, and a single price was inferred by geometric mean. CO_2 and oxygen were quantified at 0.7 and 0.23 t ha^{-1}. These figures differ from other studies, which can be related to the variations in the calculation procedure, the vegetative cover, and the studied area.

The big difference between the value inferred in the present study for CO_2 absorption and storage service and the values inferred by Yeganeh *et al.* (2015), Abbasifar (2008), Salehi and Molaei (2010) and Amirnejad (2005) can be associated with the application of different methods to estimate carbon sequestration. Some studies consider only aerial parts of the plant for carbon sequestration whilst others include subsoil organs, litter and soil, too. All in all, Sheikh Musa Rangeland ecosystem has a value of 11117.4 million IRR (318364 US $) in terms of gas regulation function. This figure shows that the Rangeland has precious socio-economic benefits that are important for the environment of the Rangeland and the region.

Recent years have witnessed extensive constructions in Sheikh Musa Rangeland (as investors and opportunists enjoying information access, purchasing personal Rangelands quickly and misusing them and also, overgrazing). These two factors are threatening the health of the Rangeland directly and the health of the region indirectly. Given what was said and the diverse products and services of Sheikh Musa Rangeland, its sound management would assure the health and economic well-being of the region. Soil and Rangeland management improves organic carbon content resulting in higher production and sustainability of the Rangelands. Finally, the following conclusions can be drawn:

1. Conducting further studies to give price models for economic valuation of carbon sequestration function of natural ecosystems.
2. Managing Rangelands on the basis of environmental principles.
3. Ceasing land use changes and overgrazing (as the most effective parameter for soil carbon management of Sheikh Musa Rangeland).
4. Conducting further studies on the value of the functions of the domestic Rangelands and enhancing public awareness (as few studies have been done on the valuation of Rangeland services in Iran).

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ارائه الگوی قیمت گذاری در ارزش کارکرد تنظیم گاز اکوسیستم‌های منابع طبیعی (مطالعه موردی: اکوسیستم مرتعی شیخ موسی، استان مازندران)

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چکیده. اکوسیستم‌های مرتعی ارائه دهنده طیف وسیعی از خدمات ارزشمند برای بشر هستند، از جمله این خدمات؛ کارکرد تنظیمی گاز می‌باشد که ارزش اقتصادی آن هنوز درک نشده است. هدف از این مطالعه محاسبه ارزش اقتصادی خدمات جذب دی‌اکسیدکربن و تولید اکسیژن با استفاده از قیمت واحد در اکوسیستم مرتعی شیخ موسی در استان مازندران بود. در این مطالعه از روش‌های قطع و توزین و فتوسنتز برای برآورد میزان ماده خشک، جذب دی‌اکسید کربن و تولید اکسیژن استفاده شد. همچنین برای محاسبه ارزش اقتصادی کارکرد تنظیمی گاز با استفاده از روش‌های؛ ارزش‌سایه‌ای، هزینه جایگزینی و هزینه اجتماعی، قیمت‌های مختلف ارائه شد و در نهایت با مقایسه آن‌ها و استفاده از میانگین هندسی قیمت واحد ارائه و سپس ارزش اقتصادی کارکرد مورد نظر برآورد شد. نتایج تحقیق نشان داد، در اکوسیستم مرتعی شیخ موسی به طور سالانه، ۲۰۸۱/۴ تن ماده خشک، ۲۴۵۴ تن اکسیژن تولید و ۷۲۹۴/۱۵ تن دی‌اکسیدکربن جذب می‌شود. ارزش کارکرد جذب دی‌اکسیدکربن با توجه به قیمت ارائه شده،۷۲۶۴/۶ میلیون ریال و ارزش اقتصادی تولید اکسیژن نیز، ۳۸۵۲ میلیون ریال برای کل مرتع در سال محاسبه شد. به طور کلی ارزش اقتصادی اکوسیستم مرتعی شیخ موسی به طور سالانه ۱۱۱۱۷/۴میلیون ریال (معادل ۳۱۸ هزاردلار) و برای هر هکتار ۱/۰۶ میلیون ریال برآورد شد. با توجه به ارزش بدست آمده که نشان دهنده حداقل ارزش اکوسیستم مرتعی شیخ موسی و اهمیت بالای کارکرد تنظیمی گاز می باشد، بنابراین پیشنهاد می‌شود که مطالعات بیشتری در زمینه الگوهای قیمتی برای اکوسیتم‌های مرتعی صورت گرفته و برای حفظ سلامت مرتع و منطقه، اصول مدیریت زیست محیطی انجام شود.

کلمات کلیدی: ارزش‌گذاری اقتصادی، تولید اکسیژن، ترسیب کربن، شیخ موسی