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CORRECTION

Correction: Economic valuation of ecosystem services in canola agroecosystems

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In the original publication of the article, the affiliation detail for author B. Kamkar was incorrectly given as "Department of Agrotechnology, Mashhad University of Ferdowsi, Mashhad, Iran" but should have been "Department of Agrotechnology, Ferdowsi University of Mashhad, Mashhad, Iran".

In addition, the affiliation detail for author A. Nadimi was incorrectly given as "Department of Plant Protection, Gorgan University of Agricultural and Natural Resources, Gorgan, Iran" but should have been "Department of Plant Protection, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran".

Finally, the affiliation detail for author H. Yeganeh was published incorrectly as "Department of Rangeland Management, Gorgan University of Agriculture and Natural Resources, Gorgan, Iran" but should have been "Department of Rangeland Management, Gorgan University of Agriculture Sciences and Natural Resources, Gorgan, Iran".

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ORIGINAL PAPER

Economic valuation of ecosystem services in canola agroecosystems

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Abstract
Ecosystem service values are divided into three categories: direct use values, indirect use values, and non-use values. In this research, the economic value of ecosystem services in canola (*Brassica napus* L.) fields was investigated during 2020–2021. These fields are located in Gorgan County (Sorkhankalateh region) north of Iran. We calculated the carbon sequestration by the carbon emission tax policy as shadow value of carbon, and to estimate some ecosystem services including the oxygen supply, grain yield and soil conservation, we applied the substitute cost methods, direct market method and replacement cost, respectively. Also, the value of pollination service was estimated along with the effect of pollinators on yield production, and the value of agrotourism estimated based on contingent valuation method. In this research, the logit model was used by the maximum likelihood method to investigate the influencing factors on people's willingness to pay. The required data for each of these variables were collected through field methods, questionnaires and face-to-face interviews with 117 visitors from the mentioned region. The results showed that the average total value of ecosystem services was equal to 3,685.91$ ha^{-1} yr^{-1}. In this research, the value of the provisioning service was equal to 1,720.81$ ha^{-1}. Also, the grain yield had the highest value among ecosystem services and accounted as 46.69 percent of all the ecosystem services. While, atmospheric services (oxygen production and carbon sequestration) included 1,155.12$ (31.34%), pollination 516.24$ (14.01%) and soil conservation 292.19$ (7.93%) of the total economic value. The share of agrotourism service from the total value of services was about 1.53$ (0.04%). In general, canola fields are more important in terms of provisioning services (grain yield) than regulating services such as oxygen production, carbon sequestration, soil conservation and pollination, as well as agrotourism services. Therefore, maintaining and enhancing market and non-market services in the canola fields of the study area is crucial for both the human and economic aspects.

Keywords Agrotourism · Canola · Direct market method · Economic valuation · Indirect valuation methods · Logit model

Introduction

Agricultural ecosystems cover a significant area of the earth's surface and are considered as one of the most influential factors on ecosystem services. If they are not exploited in a sustainable and principled manner, they will cause the deterioration of ecosystem services related to agriculture. Alternately, with negative feedback, they will cause a decrease in production of agricultural sector, and this will threaten food security at the local, national and international levels (Mohammadyari and Zarandian 2022).

The existence of such importance in this sector requires tools and ways that, in addition to accurately estimating the value of services, can explain the correct and principled solutions for political, economic and social decision-making. But the correct use of each of these methods in the case of a

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specific service is one of the challenges that should be given more attention (Perez-Verdin et al. 2016).

The functions, goods and services of ecosystems are often very valuable, but they are rarely traded in markets. For this reason and also because of the impossibility of quantitative and accurate calculations in macro-level decisions and policies, they are not given enough attention. Lack of proper understanding of the functions and services produced by ecosystems is considered a serious risk for human society. Therefore, valuation is a tool that provides useful information for managers to decide between different options. The economic valuation of ecosystems helps the planners and executives, social and economic in planning the protection and sustainable exploitation of natural resources (Duru, and Thérond 2015). In general, there are three approaches to estimate the values of ecosystem services, which include direct market valuation methods, indirect market valuation and contingent valuation method (Costanza et al. 1997 and Torras 2000).

There are various reasons for applying economic valuation techniques of ecosystem services. In the past, many of these ecosystem services were only considered as a free gift and public good from nature to the society. For this reason, there was little attention to measure the value of these services. In addition, due to the lack of the possibility of calculating their monetary values in the existing official markets, these services were often neglected in planning and decision-making in the public and private sectors. The recent development of monetary valuation methods of ecosystem services has made it possible to provide economic estimates of such benefits (Kareiva et al. 2011). Many ecosystem services can be monetized using economic methods (Farber et al. 2006). A very important aspect of monetary analysis is the use of discount rates to evaluate the present value of ecosystem services or the future value of the current benefits of the desired services, because different discount rates can produce different economic outputs (Bullock et al. 2011). Ecosystem service values are divided into three categories: direct use values, indirect use values, and non-use values. Direct use values are easier to calculate because they are often part of formal markets, including profits from the sale of products. Measuring other values is a bit more difficult, especially non-use values are challenging and can typically be estimated through techniques called contingent valuation, which involve surveys. Although some studies attempt to determine the total economic value, most of these studies cover only a subset of the value components and therefore should be considered as underestimates of the true ecosystem value (Bolt et al. 2005).

Ominski et al. (2010) addressed the economic valuation of grassland services in Manitoba Province (Canada) using the benefits transfer method and estimated the socio-economic value (1,126 million$). In other study, Bagstad et al. (2013) estimated the value of ecosystem functions in Ontario. Their results showed that the total value of ecosystem functions for the entire study area covering 12 million hectares was equal to 84 trillion$. In Denmark, Ghaley et al. (2014) conducted a study with the aim of quantifying and valuing total ecosystem services marketable and non-marketable in diverse production systems. Their results showed that the value of total ecosystem services of food and energy was equal to US$ 3142 ha^{-1} yr^{-1}. Also, in another study, Elliott et al. (2014) estimated the value of eight forest ecosystem services in Maryland at 161 million $. Sandhu et al. (2008) showed that the economic value of ecosystem services in organic agroecosystems in New Zealand was 1516$ ha^{-1} yr^{-1}, while the value of the same services in conventional agroecosystems was about 670$ ha^{-1} yr^{-1}. In Bhutan, Kubiszewski et al. (2013) investigated the economic value of ecosystem services using the benefit transfer method. Their results showed that the economic value of services was equal to 15.5 billion$ yr^{-1}. Estrada et al. (2015) estimated the economic value of climate regulation in Thailand about 455.82 US$ million. Also, Balasubramania (2020) estimated the global economic value of regulating services at 29.085 trillion $ in 2015 and reported that climate regulation had the largest share in the total value of ecosystem regulating services.

Canola plant (*Brassica napus* L.) as an oilseed plant has found a good adaptation to the conditions of Golestan province north of Iran. Also, this plant has a valuable place in cropping rotation in terms of improving soil properties through deep and vertical roots and the optimal combination of plant residues and reducing pests, diseases and weeds in the fields of grain crops, and due to its high ability to compete with grasses. In Iran, Golestan province has the first rank in terms of the cultivated area of canola, with 50,983 ha, which has 32.3% of the cultivated area of canola in the country. Also, the amount of canola production in Golestan province was 109,175 t, which accounted for 31.1% of the total canola production of the Iran. In Golestan province, 30% of canola fields are irrigated and 70% are cultivated under rainfed farming systems, and the average yield was reported 2.14 t ha^{-1}. The cultivated area of canola in Gorgan is 5525 ha and its production amount is 9417 t, of which the Sorkhankalateh region with the cultivated area of 704 ha has about 1410 t of the total production in Gorgan (Agricultural Organization of Golestan Province, 2020). Considering the importance of canola in Golestan province and also in Iran, the quantification and valuation of non-market and market services can clarify the current situation of ecosystem services in the landscape level, management strategies regarding the optimal and efficient use of all types of ecosystem services, protection of all services as a platform for sustainable development and increasing the provision of ecosystem services instead of services losses.

Materials and methods

Study area

This study was carried out in the Sorkhankalateh region of Gorgan County, North of Iran. Sorkhankalateh region is located in the northeast of Gorgan County in Golestan province with longitude 54° 35′ E and latitude 36° 54′ N (Fig. 1). It is located in a flat region with 51 m altitude and its climate is temperate with rainfall in autumn, winter, and early spring. In July and August, the weather in this region is hot and humid. Due to its favorable climatic condition, Sorkhankalateh has the necessary potential to produce

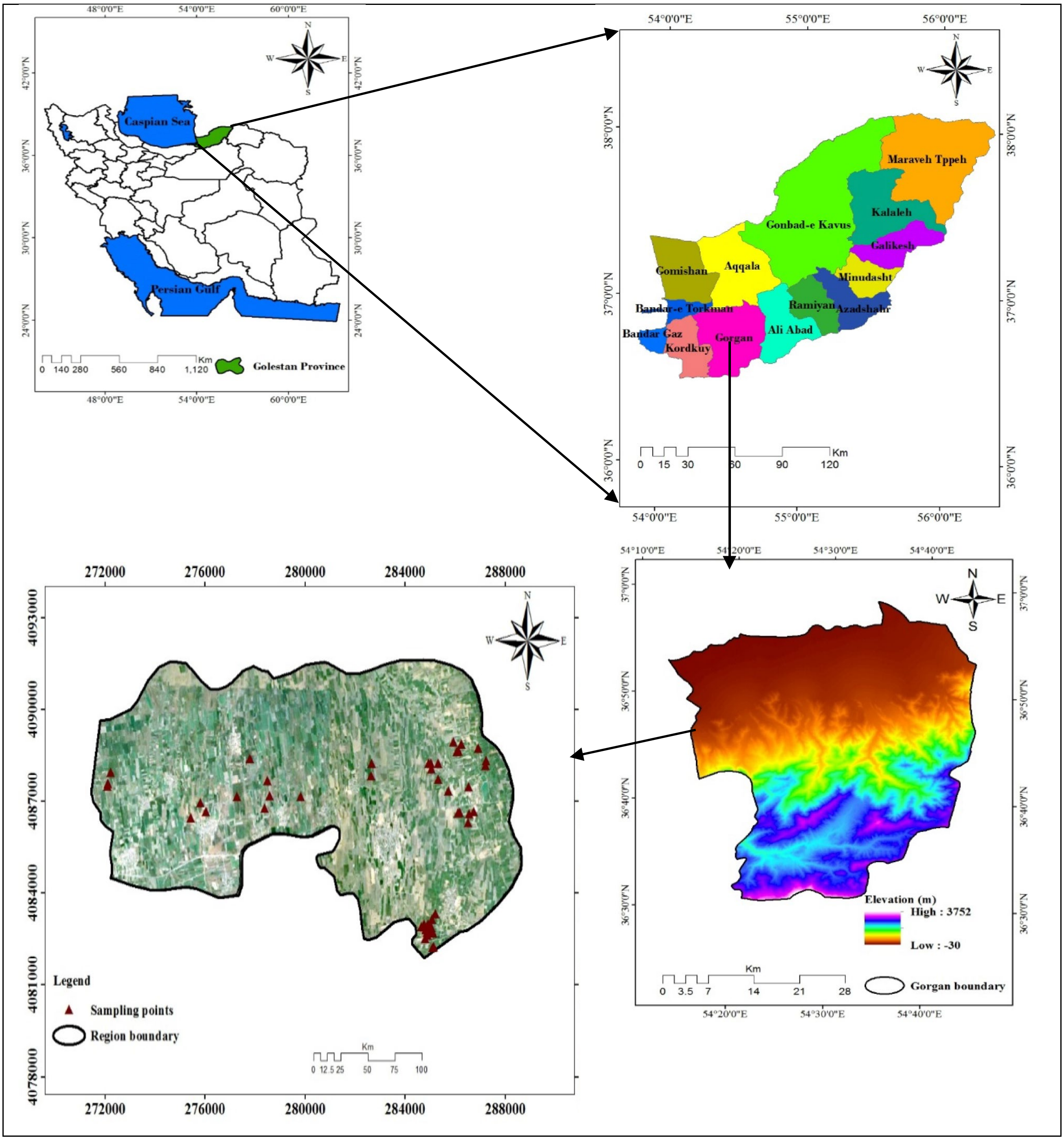

Fig. 1 Location of Sorkhankalateh region and sampled canola fields, Golestan provin

some crops such as canola, potatoes, wheat, barley, corn, faba bean and soybean (Agricultural Organization of Golestan Province, 2020).

Quantification of ecosystem services

In order to calculate the soil carbon sequestration, sampling was done in two stages, before planting and after crop harvest (early November and mid-June) from 50 canola fields based on Cochran's formula. Sampling was done based on the W pattern (Thomas 1985). Based on area, the fields were divided into three groups: "a", fields with < 5 ha, "b", fields between 5 and 13 ha, and "c", fields > 13 ha (Fig. 2). The geographical coordinates of the points were recorded using a GARMIN MAP 72CSX GPS device.

Soil sampling was done by auger and shovel down to 30 cm, and grain yield and biomass were harvested by quadrates of 0.5 × 0.5 square meters. The number of quadrates was different based on the area of each field according to W pattern. Plant carbon storage was measured using the electric furnace method and soil organic carbon was measured using the Walkley–Black method. The amount of oxygen production was also calculated based on the amount of plant dry matter. To estimate soil conservation, the erosion rate in the study area was determined using revised universal soil loss equation (RUSLE) model.

In order to collect insects, an insect net with an opening diameter of 40 cm, handle length of 120 cm and transparent silk material was used. Sampling was done during two stages (from mid-March to late April) at several points randomly on the field level. Also, sampling hours were during the peak activity of insects and in favorable weather conditions (sunny weather and no strong wind) from 9:00 AM to 3:00 PM.

Questionnaire and survey methods were used to estimate the agrotourism service during the canola growing season in the study area. In this survey, we were interviewed from 117 people of native and non-native visitors who traveled to the target region during March and spring.

Economic valuation of ecosystem services

A variety of valuation methods such as carbon emission tax (carbon shadow value), replacement cost method, contingent valuation method (CVM) and direct market valuation method were used for the economic valuation of ecosystem services (Table 1).

Supplied O_2

In order to determine the economic value of O_2 production, the cost of the industrial and medical of O_2 gas was used as a direct market method. In the industrial section, O_2 gas is prepared by compressing air in special capsules, as a result of this process, O_2 gas becomes liquid (separated from other substances) and comes out of the compressor. In this study,

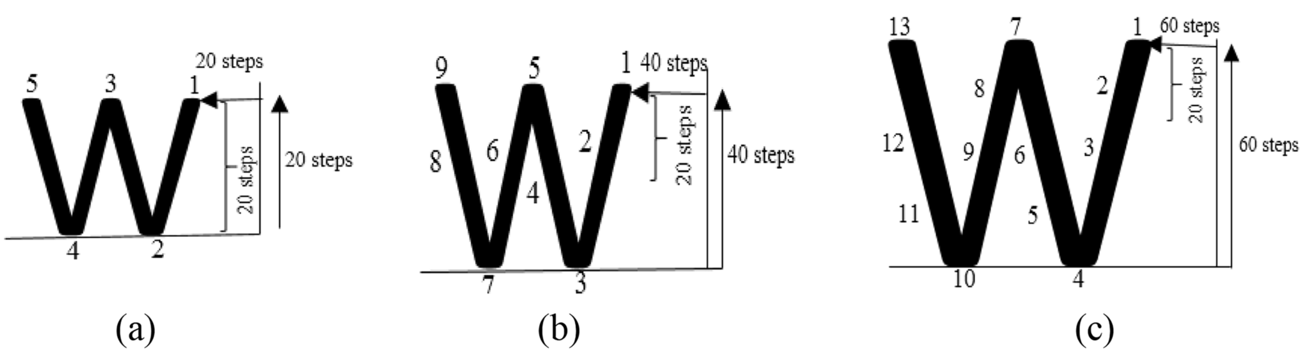

Fig.2 Sampling based on W pattern in fields under three groups a, b and c (Kazemi 2016)

Table 1 Valuation methods of ecosystem services in the canola fields, Sorkhankalateh region of Gorgan County, Iran

Services	Method	References
O_2 production	Alternative cost method	Li et al. 2006
Carbon sequestration	Carbon tax policy method (Shadow value)	(Strange et al. 1999)
Pollination	Along with the interposition effect of pollinators	Abrol 2012; Hosseini et al. 2019
Soil conservation	Replacement cost method	Xue and Tisdell 2001; Li et al. 2006
Provision	Direct market method	Amirnejad and Ataiesolout 2011
Agrotourism	Contingent valuation method	Whitehead et al. 2008

an amount of 21.97$ t^{-1} was used to determine the oxygen value in canola fields. Then, by multiplying the cost of each unit of O_2 supplied by canola field, the total economic value of the O_2 production was calculated (Li et al. 2006).

Carbon sequestration

The carbon tax policy and carbon emission reservoirs were used as the shadow value of carbon for carbon valuation (Strange et al. 1999). In this method, to determine the value of carbon accumulated in canola fields, the amount of carbon accumulated in the entire aerial parts without seeds, underground and soil was calculated. The total carbon stored by canola includes the carbon stored in the aerial+ underground parts and the soil part

$$C_1 + C_2 = CT \tag{1}$$

where C_1 and C_2 are the amount of carbon stored in aerial and underground parts and soil, respectively (Moulai 2018). Then, the carbon shadow approach was used and this measurement was done by applying the average tax rate applied for the emission of each ton of carbon in the amount of carbon deposited in the farms. In this study, the average price of $ 60 (Pache et al. 2020) was used as the cost of carbon sequestration per ton of carbon.

Soil conservation

In order to value the service of soil conservation, the replacement cost method (price of chemical fertilizers) was used (Xue and Tisdell 2001; Li et al. 2006). In this method, first, the amount of soil erosion was estimated at the level of the region. Then, the amount of soil preserved in the farms of the region was also calculated. In the next step, the loss of the main soil nutrients (N, P and K) was calculated in grams per kilogram. The market value of these fertilizers can be an estimate of the ecosystem service value of soil erosion control by agroecosystems. Also, considering that the ratio of nitrogen, potassium and phosphorus in the mentioned fertilizers, the price of the fertilizer was multiplied by the percentage of elements in fertilizers.

Provisioning services

In order to evaluate the provisioning services, according to the product yield and also utilizing the guaranteed price of the canola market in 2020–2021 (0.52$ kg^{-1}), the economic value of canola production was determined using the following Eq. (2).

$$V = P \times Y \tag{2}$$

where V: the total value of the productive function of each hectare, P: the market price of each kilogram of the product, Y: the yield of the product per hectare (Amirnejad and Ataiesolout 2011).

Pollination service

First, the value of the canola product was determined with the role of pollinators and according to the price of the canola yield in the market. Then, the value of the pollination service in canola fields was calculated. In other words, the amount and the price of the production were calculated, then considering the dependence of canola on pollinating insects (30%), (Stanley et al. 2013), the economic value of pollination in the canola fields was calculated from Eq. (3).

$$Ve = Pn \times Fe \times Ps \tag{3}$$

where Ve: the economic value of the pollination service, Pn: the amount of canola production, Fe: the dependence of canola on pollinating insects, and Ps: the price of canola in the market (Abrol 2012; Hosseini et al. 2019).

Agrotourism service

We were applied the conditional valuation method (CVM) (Whitehead et al. 2008) to determine the effective factors on people's willingness to pay and estimate the tourism value of this region. Also, in order to determine the number of required questionnaires, proposed amounts and solve possible problems, 30 pre-test questionnaires completed and were asked from the visitors about their maximum willingness to payment. Finally, the number of required questionnaires was determined based on the formula provided by Michel and Carson (1989).

$$n = \left[\frac{t \times v}{d}\right]2 \tag{4}$$

where n is the sample size, t is the statistic value (t-student), $t = 1.96$, V is the coefficient of variation and d is the difference between the actual and estimated willingness to pay. The value of d is determined by the researcher.

The nominal logit regression model has been used to investigate the effect of different explanatory variables on the willingness to pay of visitors for tourism value. The suggested amounts are first expressed to the visitors as an entrance to the area, and the visitors, since they maximize their utility, propose acceptance and non-acceptance options in front of the proposed proposals. To determine the measurement model, it is assumed that each visitor is willing to pay an amount of his income to use the environmental resource as the proposed amount (A), which will create utility (U) for him. The amount of utility generated by the use of environmental resources is more than the case where he does not use environmental resources, which is shown by Eq. (5) (Lee and Han 2002):

$$U(1, Y - A; S) + \varepsilon_1 \geq U(0, Y; S) + \varepsilon_0 \quad (5)$$

where U is the indirect utility function, Y is the individual's income, S is a vector of other economic-social factors of the individual, ε_0 and ε_1 are random variables with zero mean that are distributed randomly and independently of each other. The difference created in the utility (UΔ) due to the use of the environmental resource is expressed according to Eq. (6).

$$(U\Delta = U(1.\ Y - A;S) - U(0.Y;\ S) + (\varepsilon 1 - \varepsilon 0) \quad (6)$$

The double questionnaire structure in examining people's willingness to pay has a dependent variable with a double choice based on the probability logit model (Pi), that the person accepts one of the offers, is expressed in the form of relation (7) (Lee and Han 2002).

$$Pi = F_\eta(\Delta U) = \frac{1}{1 + \exp(-\Delta U)} = \frac{1}{1 + \exp(-(a + \beta A + \gamma Y + \theta S))} \quad (7)$$

In this regard, Fη (ΔU) is a cumulative distribution function with a standard logistic deviation and includes some socio-economic variables such as income, proposed amount, age, gender, household size and education. β, γ and ϴ are estimable coefficients that are expected to be $\beta \geq 0$, $\gamma^{>} 0$ and $\Theta^{>} 0$. The parameters of the logit model were estimated by the maximum likelihood method using Shazam software version 10. It should be noted that 117 questionnaires were collected from native and non-native visitors who traveled to the target region during March and spring.

Results

The economic value of gas regulation in canola fields includes the total economic value of carbon dioxide absorption by vegetation and soil and the economic value of oxygen release. Table 2 shows the value of carbon accumulation per hectare. Considering that the annual average of carbon accumulation is 16.49 t ha^{-1}, the equivalent value of carbon accumulation by canola cropping in Sorkhankalateh region was equal to 989.73$ ha^{-1}. Also, considering that the average production of oxygen is 7.52 t ha^{-1}, the value of each hectare of canola fields in terms of oxygen supply was calculated as 165.38$. According to the results of economic values of oxygen production and carbon sequestration, the total value of gas regulation service was estimated as 1,155.12$ ha^{-1} (Table 2).

According to the obtained results, the average grain yield was about 3.29 t ha^{-1}. Therefore, the value of provisioning services in canola fields was calculated as 1,720.81$ ha^{-1} annually (Table 2). Valuing of canola in Iran is done by the direct market method and in the form of guaranteed purchase by the government. Therefore, the proposed rate by government has a direct role in the development or non-development of cultivated area and the production of this plant in different regions of Iran.

Table 2 The annual economic value of carbon accumulation, oxygen production, pollination, grain yield, soil conservation and tourism service in Sorkhankalateh region of Gorgan County, North of Iran

Service	Average economic value ($ per hectare)	Percentage
Gas regulation	1,155.11	–
Carbon accumulation	989.73	26.85
Oxygen production	165.38	4.49
Grain yield	1,720.81	46.69
Pollination	516.24	14.01
Soil conservation	292.19	7.93
Agrotourism	1.53	0.04
Total	3,685.88	100

Table 2 shows the value of the pollination service in the canola fields. The value of pollination was estimated as 516.24$ ha^{-1} (Table 2). Forty-seven species of pollinating insects belonging to 13 families and 4 orders were identified. It was found that the majority of species, belonging to the order Hymenoptera (46.4%), followed by Coleoptera (26.07%), Diptera (21.15%) and Lepidoptera (6.41%), were ranked in the subsequent places.

The economic value of soil conservation in canola fields of Sorkhankalateh region was calculated as 292.19$ ha^{-1} in (Table 2). This price estimate represents the opportunity cost of the existence of agricultural ecosystems in the region in maintaining and fertility of the soil.

The social and economic characteristics of visitors to canola fields are given in Table 3. Of the total visitors, 66.3% were men and 33.7% were women, while 63.5% of people were married and 36.5% were single. The average age of the participants was 39.77 years. The average monthly income variable was also equal to 210.91$ per month and it was also determined that the average number of people in the household (household size) is 3.68 people.

The frequency percentage of visitors in different age groups showed that in terms of age, most of the visitors were in the age group of 30–50 years (70.2%) and the least number of them were in the age group of more than 50 years (14.4%). The findings of this research show that 33.7% of the visitors are self-employed and 26% are employees (Table 4).

The questions related to the willingness to pay are raised in such a way that the middle offer is questioned first is given in Table 5. If the visitors give a negative answer, they will be asked for a low price offer, and if the visitors give a positive answer, the visitors will be asked for a high offer price. This

Table 3 - Socio-economic characteristics of visitors to canola fields in Sorkhankalateh region of Gorgan County, North of Iran

Variables	Mean	Standard deviation	Minimum	Maximum	Description
Middle offered price	0.27	3162.2	0.13	0.52	Dollars
Satisfaction with nature	4.08	0.82	2	5	–
Number of visits per year	2.23	1.07	1	4	–
Visiting the area	0.87	0.33	0	1	Yes = 1 and No = 0
Duration of each visit (hours)	2.88	1.04	1	4	Hours
Overnight stay	0.31	0.46	0	1	Yes = 1 and No = 0
Cultural compatibility	3.29	0.69	1	5	–
Gender	0.66	0.47	0	1	Woman = 0 and Man = 1
Status Marriage	0.36	0.48	0	1	Married = 0 and Single = 1
Age	39.77	9.96	22	62	Year
Education	15.62	3.96	0	22	Year
Household size	3.68	0.88	1	5	People
Willingness to revisit	0.92	0.26	0	1	Yes = 1 and No = 0
Monthly income	210.91	2.07	43.94	307.58	Dollars
Final destination	0.33	0.47	0	1	Yes = 1 and No = 0
Distance	102.82	263.32	1	1476	Km

Table 4 Distribution of job and age frequencies of visitors from Sorkhankalateh region of Gorgan, North of Iran

Distribution of job frequency (%)								
Occupation	Employee	Academic staff	Teacher	Housekeeper	Farmer	Self-employment	Other	Total
Percentage	26	4.8	2.9	11.5	7.7	33.7	13.5	100
Distribution of age frequency (%)								
Age	Under 30 years	30–50 years	More than 50 years	Total				
Percentage	15.4	70.2	14.4	100				

Table 5 Willingness to pay of visitors in canola fields of Sorkhankalateh region, Gorgan County, North of Iran

Acceptance status	Low offer		Middle offer		High offer	
	Number percentage		Number percentage		Number percentage	
Acceptance	20	19.2	43	41.3	21	20.1
Non-acceptance	41	39.4	61	58.7	22	21.1
Total	61	58.7	104	100	43	41.3

level of willingness to pay was obtained through initial questions from people through a questionnaire, and these middle, minimum and maximum amounts were suggested as 0.26, 0.13 and 0.52 $ for each visit to the region, respectively. The results showed that 58.7% (61 people) did not accept the initial offer and did not want to pay 0.26$ to visit the area, while 41.3% (43 people) accepted it. When a lower offer of 0.13$ was presented, 39.4% (41 people) did not accept this offer, while 19.2% (20 people) accepted it. On the other hand, those visitors who accepted the initial offer, when a higher amount of 0.52$ was offered for each visit to the area, about 21.1% (22 people) did not accept the above offer and 20.1% (21 people) accepted proposals to increase the amount more than 0.52$.

To estimate the logit model, social and economic variables that have a great impact on people's willingness to pay to visit the region were used. Due to the lack of proper results in the initial model, the variables that reduced the efficiency of the model, such as the visiting season and the reason for choosing the region, were removed from the model. Also, the household income variable, which is affected by the individual's monthly income, was excluded from the model and the individual's monthly income variable was used. Finally, the model with variables such as the level of satisfaction with nature, the number of visits per year, the duration of each visits (hours), and the willingness to stay was available. The cultural and social compatibility of the area with individual desires, gender, status marriage, age, education, household size, willingness to revisit, monthly income, final destination and distance were implemented. Among them, 13 questionnaires were removed due to misunderstanding of WTP questions and incompleteness. Finally, the analysis of the cultural value of canola fields was done with 104 questionnaires.

The results of estimating the coefficients, statistical probability levels and the influence of variables on the dependent variable using maximum likelihood are shown in Table 6. The results of the logit model estimation revealed that the coefficient of the variables of the number of visits per year, age and monthly income at the level of one percent and the variables of visiting the region and the final destination at the level of 5 percent and the variables of gender, willingness to revisit and the middle offered price at the probability level 10% were significant (Table 6).

The statistical value of the probability ratio obtained in Table 6 was equal to 64.80. This value, according to the probability of the likelihood ratio, indicates that the estimated model is generally meaningful. The values of CRAGG-UHLER explanatory coefficients for the estimated logit model were equal to 0.36. These values are a favorable amount according to the number of observations of the dependent variable. The correct prediction percentage of the estimated model was over 74%, that is, 74% of the respondents have correctly assigned the predicted willingness to pay yes or no by providing a completely appropriate ratio of information (Table 6).

The expected value of WTP, which shows the recreational value of the study area, was calculated after estimating the logit model using the maximum likelihood method, by integrating by replacing the mean values and other explanatory variables and calculating the width from the adjusted origin. In this study, average WTP is used. The predicted amount of WTP was calculated by numerical integration in the range of zero to the highest offer of 0.52$ using the following equation.

$$WTP = \int_0^{0.52} \frac{1}{1 + \exp(-(-1.0295 - 0.000093238 * bid))} = 0.14\$ \tag{8}$$

As can be seen, the average willingness to pay for each person to use the study area in each visit was 0.14$. Based on the average number of annual visits by tourists to canola fields (about 2.2 visits per year), the willingness to pay annually was estimated as 0.31$ for each person to visit this region.

In order to calculate the total recreational value, the expected value of the willingness to pay per person per visit was multiplied by the annual number of tourists in

Table 6 The results of estimating the nominal logit regression model for the recreation value of Sorkhankalateh region; Gorgan County, North of Iran

Variables	Estimated coefficient	Statistical value(t)	Weighted elasticity of variables	Final effect
Middle offered price	− 0.00009	− 1.62*	− 0.38	− 0.26
Satisfaction with nature	0.29	1.13	0.76	0.52
Number of visits per year	− 0.58	− 2.91***	− 0.84	− 0.54
Visiting the area	1.75	2.50**	0.98	0.69
Duration of each visit (hours)	0.09	0.57	0.17	0.12
Overnight stay	-0.63	− 1.50	− 0.13	− 0.081
Cultural compatibility	0.31	1.18	0.67	0.45
Gender	0.75	1.65*	0.32	0.21
Status Marriage	− 0.58	− 1.23	− 0.13	− 0.10
Age	− 0.08	− 3.32***	− 2.16	−1 .42
Education	0.006	0.13	0.070	0.047
Household size	− 0.06	− 0.29	− 0.15	− 0.10
Willingness to revisit	1.63	1.72*	0.97	0.67
Monthly income	0.31	2.85***	0.97	0.68
Final destination	1.08	2.61**	0.23	0.16
Distance	0.0006	0.88	0.039	0.028
Fixed coefficient	− 2.78	− 1.46	− 1.78	− 1.19

Likelihood ratio test = 64.80, D.F = 16, p value = 0.00000, percentage of right predictions = 0.74, log-likelihood function = -107.90, log-likelihood(0) = -140.30, cragg-uhler r-square = 0.36

Significance at the one percent level***, Significance at the five percent level**, Significance at the ten percent level* the study area. Considering that there were no statistics on the number of annual tourists from the region, therefore, in order to calculate the annual economic value of this region, the population of Sorkhankalateh was used as the dominant tourists of the region. Thus, under the scenario of 5%, that is, if 5% of the population of Sorkhankalateh visits the canola fields annually, what will be the annual value of this region? According to the population of 7,589 people of Sorkhankalateh if 5% of the population of Sorkhankalateh (3,794 people) visit the region annually, the annual economic value of this region will be equal to 520.04$. In the second scenario, if only 10% of the population (7,589) visit the region annually, the economic value of this region was estimated to be 1,080.22$, which indicates the high value of canola fields from the point of view of tourists. Also, considering that the cultivated area of canola fields in the studied area in 2020 was equal to 704 ha, the economic value of each hectare of canola fields was estimated as 10% and 5% scenario as 1.53 and 0.76$, respectively.

Figure 3 displays the economic value of each hectare of canola fields in the study area. The fields located in the western, northwestern, and southwestern parts, and few fields located in the eastern regions, hold more value than those located in the northern, northeastern, southern, and southeastern areas.

Discussion

The equivalent value of carbon accumulation by canola cropping in studied region was equal to 989.73$ ha^{-1}. Canu et al. (2015) estimated the economic value of carbon sequestration for the Mediterranean Sea between 127 and 1722 million € yr^{-1}. Also, Banasiak et al. (2015) estimated the economic value of carbon sequestration in US national parks at 40.45 million $. In this study, the total value of gas regulation service was estimated as 1,155.12$ yr^{-1}. In other study, Iranmensh et al. (2020) obtained the economic

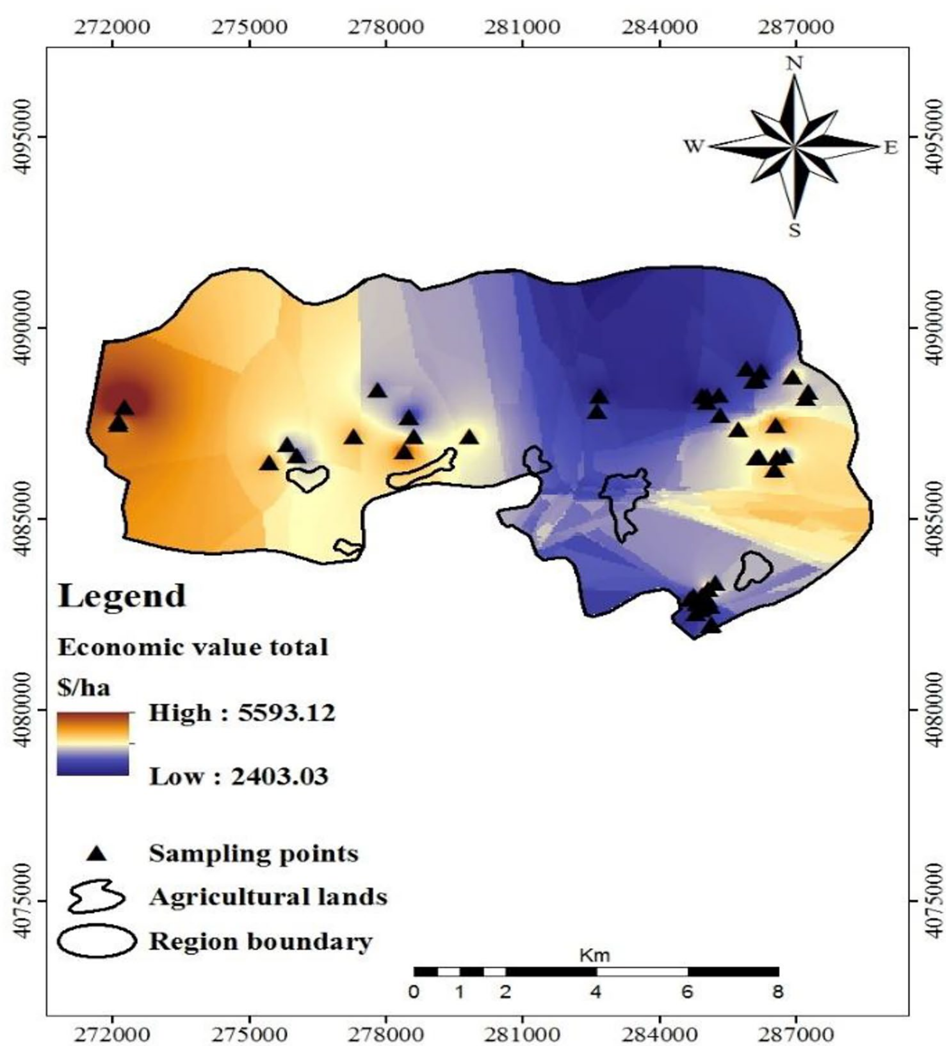

Fig.3 Map of total economic value of canola fields in Sorkhankalateh region, Gorgan, North of Iran

value of oxygen production within the Gandoman wetland, located in the Chaharmahal and Bakhtiari Province of Iran, to be 11,189,600 Rials ha^{-1} yr^{-1}. Also, Yeganeh et al. (2015) estimated the economic value of oxygen production in the Teham watershed in Zanjan province, Iran as equal to 10,777.4 million Rials yr^{-1}.

The value of provisioning services in canola fields was calculated as 1,720.81$ ha^{-1} annually. Basically, valuing of canola in Iran is done by the direct market method and in the form of guaranteed purchase by the government. The proposed rate by the government has a direct role in the development or non-development of the cultivated area and the production of this plant in different regions. In this regard, Koocheki et al. (2017) estimated the economic value of wheat fields in Razavi Khorasan Province (northeast of Iran) equal to 66.85×10^6 Rials ha^{-1} yr^{-1}, after deducting the value of negative consequences. Bostan et al. (2022) estimated the value of provisioning services (fodder production) about 198,767.75$ yr^{-1} for the entire pasture ecosystem of Sheikh Musa watershed (north of Iran). Ghaley et al. (2014) reported that the value of food and energy in diverse production systems in Denmark was equal to US$ 3, 142 ha^{-1} yr^{-1}.

In this study, the value of pollination was estimated as 516.24$ ha^{-1}. Bostan et al. (2022) estimated the economic value of insect pollination services in the ecosystems of the northern pastures of Iran. The results showed that the value of pollinating insects per hectare and the total ecological components of Iran's pastures were 63.37 and 649,096.5$, respectively. Also, Breeze et al. (2015) and An and Chen (2011) also estimated the economic value of pollination as 379 million $ in fruits and vegetables in the United Kingdom and 10.6 billion € in fruits and vegetables in China, respectively.

According to the results, the economic value of soil conservation in canola fields of Sorkhankalateh region was calculated as 292.19$ ha^{-1}. Due to wide and spongy leaves, canola completely covers the ground and prevents soil erosion especially in the early stages of growth. Also, its vertical and straight roots penetrate the soil and protect the soil. Rastgar et al. (2016) reported that the highest value of soil conservation in summer pastures in the Nour-Rud watershed, Mazandaran province (Iran), is related to density of pastures (10.86 billion Rials) and the lowest value is related to low-density pastures (1.31 billion Rials).

In this study, the coefficients of the variables of monthly income, number of visits and education were positive and this means that the probability of accepting the proposed amount is higher in people with higher income, more education and people who have more number of visits. Also, the variable coefficient of the proposed price in the middle is negative and this indicates that the probability of acceptance decreases with the increase of the proposed amount. Also, the coefficient of variables such as age, marriage, and household size is negative and gender is positive, which means that young, single, and male people tend to pay more than old, married, and female people, and also larger households tend to pay less.

The annual economic value of agrotourism in this region was estimated about 1,080.22$. In other study, Ominski et al. (2010) estimated the socio-economic value about 1,126 million$ for grasslands services of Manitoba Province in Canada.

Finally, the value of ecosystem services of canola fields was equal to 3,685.91$ ha^{-1} yr^{-1}. It seems that some factors contribute to increase of this value, such as accessibility to water resources, near to forest ecosystems, the existence of honey bee beehives in near the fields, the existence of trees around the fields and near to the road. Also, the reasons for the decrease in economic value can mention the low coverage of the area, burning of plant residues, and tillage operations.

Conclusion and outlooks

The results showed that agricultural ecosystems, despite their multi-functional nature, are able to provide services such as carbon sequestration, oxygen production, pollination, soil conservation, and agrotourism in addition to provisioning services, whose economic value has been significant. In general, the results showed that the total annual value of ecosystem services in canola fields was equal to 3,685.88$ ha^{-1} yr^{-1}. The share of each of the measured services including oxygen production, carbon sequestration, grain yield, pollination, soil conservation and agricultural tourism were 165.38, 989.73, 1,720.81, 516.24, 292.19 and 1.53$ ha^{-1}, respectively. Also, the results showed that the average willingness to pay for each person to use this region per visit was 0.14$. Based on the average number of annual visits of tourists to canola fields in the region (about 2.2 visits per year), the willingness to pay annually for each person to visit the region was estimated to be 0.31$, which is due to the low willingness of the community to pay, it seems reasonable. Also, according to the few studies in the field of mentioned services, it is suggested that the functions and indirect services of agroecosystems should be addressed in future studies in the direction of policy-making and proper management.

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Code availability Not applicable.

Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethics approval No approval of research ethics committees was required to accomplish the goals of this study because experimental work was conducted with an unregulated invertebrate species.

Consent to participate The authors have no consent to participate to declare that are relevant to the content of this article.

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