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Opinion Article

Evaluation and valuation of tajan river basin ecosystem services

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ABSTRACT

Rivers as a blue ecosystem have a lot of ecosystem services that awareness of the value of their services will protect them as much as possible and communities will benefit from their environmental services. In this study, Tajan river basin ecosystem services in the north of Iran was valuated. To valuate, the choice experiment method was used to estimate willingness to pay. Tajan river basin ecosystem services attributes including regulating, supporting, provisioning and cultural services and a price attribute at three levels were determined. Data from 239 resident households of Mazandaran province were used in 2017. The empirical analysis did by the conditional logit model and mixed logit model. Also, multi criteria decision making including techniques Entropy, TOPSIS and SAW used for evaluating the role and importance of the Tajan river basin ecosystem services. The findings indicated that residents were willing to pay for the conservation of Tajan river basin ecosystem services, 13.77 USD per year. It was for regulating, supporting, provisioning and cultural services of Tajan river basin, 2.62, 6.30, 2.50 and 2.35 USD per year to move away from the status quo to the improvement status respectively. Also, findings of weighting and prioritization of Tajan river basin ecosystem services with TOPSIS and SAW methods showed that supporting and provisioning services had the highest weight for the evaluation Tajan river basin ecosystem services. In other words, the residents prefer the services as the most important Tajan river basin ecosystem services. Results showed that willingness to pay can be introduced as a useful tool to investigated people's preference for conservation of river basin ecosystem services under various activities. Therefore, by determining the value of river ecosystem services, community will understand that river services are of great importance, and the application of its value in calculations related to comprehensive management of basin water resources will provide a suitable economic solution to increase user utility the river.

1. Introduction

The ecosystem provides various services including provisioning, regulating, cultural and supporting services (habitat for species) (MEA, 2003; Yang et al., 2020). In spite of the obvious benefits of Ecosystem Services (ES), their value remains challenging to quantify, because they're non-market goods (Li et al., 2021; Johnston et al., 2017). The evaluation procedures can measure the number of services exactly, but it does not reflect their significance to society. The valuation methods such as stated preference valuation procedures can reflect 'people's Willingness to Pay (WTP) for the ecosystem services and so provide a reference for setting environmental restitution standards and the social development sustainability (Obst et al., 2016; Wang et al., 2017, 2018). Conditional Valuation method (CV) and Choice Experiment (CE) are stated preference valuation methods that were used to survey the respondents' WTP.

In CV procedure asked respondents whether or not they could support financially and within the case of public goods, also politically a proposed change in the extent of provision of a group of goods or services. The second approach known as CE used in the early 1980s firstly in Louviere and Hensher (1983) articles (Badura et al., 2020; Dugstad et al., 2021). In contrast to CV in CE method various attributes of the proposed good or service to be improved are selected during the planning phase of the CE (Badura et al., 2020; Dugstadet al., 2021). Then, the respondents are asked their desired scenario choose from different options with different levels of features (Badura et al., 2020).

The aim of this study is to investigate the WTP for Tajan River Basin Ecosystem Services (TRBES) using the CE method. The shortage of information and insufficient knowledge of the river basin's natural ecosystem services has led to a rise the number of damages to the river

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basin unfortunately (Symmanka et al., 2020; Liu et al., 2021). Therefore, the study must know ES of river basin and restore and protect them. Multi Criteria Decision Making (MCDM) is a method to identify evaluate of ecosystems functions and services. Also, MCDM is a technique for solving complex decision-making (Mulliner et al., 2016). They are used for weighting and prioritizing functions and services ecosystems (Penga et al., 2015).

A review of studies did about CE revealed that extensive studies have been conducted about river ecosystem services by using revealed and stated preference is done around the world including; Zander and Straton (2010) valuated Australians tropical river ecosystem services. The results showed that the majority of respondents preferred healthy river services. Bliem et al. (2012) compared the findings results done on the Danube River among the Austrian capital of Vienna and the border to the Slovak Republic in 2007 and 2008. The findings showed that preferences and WTP aren't sensitive to time. Also, Alcon et al. (2014) evaluated farmers' WTP of policy strategies to river basin water supply in Spain. The findings indicated farmers are willing to pay twice as much as their current irrigation water price for ensure water supply via administration supply guaranteed schedules. Hu et al. (2019) used a multi-source data for assessing the patterns of the ecosystem service value within the Pearl River Delta from 1995 to 2015. The result showed that the ecosystem service value changed due to anthropogenic activities within the Pearl River Delta. In another study, Hua et al. (2020) surveyed changes of ES values in areas of China using Land Use/Land Cover (LULC) data and benefit transfer method during 1992–2015. The findings revealed that ecosystem service values such as regulating, supporting, provision and cultural services were 69.05%, 18.23%, 8.54% and 4.15% to the total ecosystem service values respectively. Also, Wu et al. (2022) estimated the value of ecosystem services of Qinghai-Tibet Plateau using land use data from 1980 to 2010. The study results showed that value of the region's ecosystem services increased compared to the past.

Other Choice Experiment (CE) studies that stated economic valuation of river basin ecosystem services by investigating people's preference showed in studies such as Price et al. (2016) to investigating water-scarce environments heterogeneity in Nepal's Koshi River Basin and Lizin et al. (2016) to investigate people's preference for Oude Kale and Leie Rivers; Rudd et al. (2016) for little-known Canada's species at risk Aquatic; Chaikaew et al. (2016) for surveying preferences and MWTP of ecosystem services under different scenarios in a mixed-use watershed in the Suwannee River Basin. Also, Bergstrom and Loomis (2017) used CE for river restoration economic valuation; Kahn et al. (2017) estimated the population's willingness to pay for restoring the Rio Paraiba do Sulu using CE and Enriquez-Acevedo et al. (2018) surveyed WTP respondents at three beaches within the Colombian Caribbean Region with CE.

In this regard, Costa and Hernandez (2019) to investigate WTP using of employing a stated preference approach in the Taravo River basin used CE and Kunwar et al. (2020) for conducting public preference for Danda river basin restoration. Also, researchers such as, Sieber and Pons (2015) used MCDM in Singapore city; Xu et al. (2019) in the Manas River Basin; Hua and Chen (2019) used Importance Performance Analysis (IPA) in the China Urban River for prioritization and evaluation of China Urban River Basin Ecosystem Services.

The study's results showed that supporting services had been the most important from the perspective of riverside residents. Despite the various CE application on river basin ecosystems, the CE method in Iran is widely practiced in the valuation of the forest and rangeland ecosystem services. But there were very few studies for evaluation and valuation of river basin ecosystem services using CE and MCDM in Iran.

Although Iran is located in the arid and semi-arid region of the world, it includes many watersheds that are important for this Iran. The most important watersheds of Iran are the watersheds of the Caspian Sea, the Persian Gulf and the Oman Sea, Central Desert, Sistan and other internal watersheds of Iran. One of the important basins of the Caspian Sea is the Tajan River Basin (TBR) in Mazandaran province, which is the foundation of economic activities in this province. A large part of the land along the TBR is mainly dedicated to rice cultivation. Also, TBR plays an important role in providing drinking water and agriculture in the cities of Mazandaran province. In spite of its antiquity, importance and many services the TBR has for its beneficiaries, in recent years has been faced with people's inattention and mismanagement by managers, decision makers and planners. The increase in population growth and the development of cities, economic-social activities, authorized and unauthorised extraction of sand from the bed and banks of the TBR have caused the destruction of this ecosystem (Jollodar Naderi et al., 2016). Finally, it will dry up, reduce biodiversity and reduce the services of this water ecosystem of the river in the feature years.

Therefore, the basic propose of the research is identification of Tajan River Basin Ecosystem Services (TRBES) and an investigating the preferences and WTP Mazandaran province residents (households) for the TRBES valuation and, weighting and prioritization TRBES for the evaluation of river basin ecosystem services. Because, Tajan River Basin is one of the main rivers basin in northern Iran which stresses from the scarcity of water resources within the past decade led to the drying up of the river basin for a few years. Also, the probability of such tensions occurring or exacerbated by climate change within the future years is increased.

2. Materials and methods

2.1. Site information

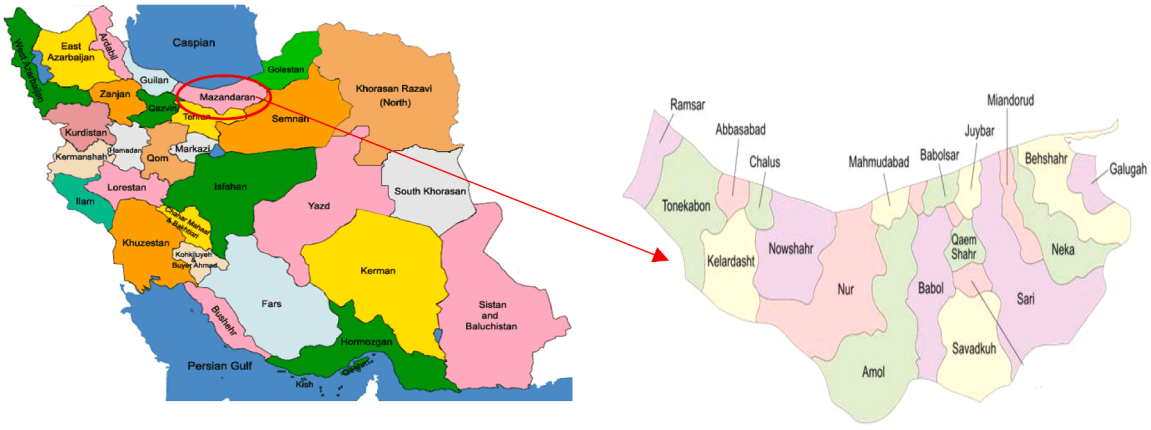
Tajan River Basin (TBR) is the main rivers of northern Iran that it located in Mazandaran province of northern Iran (Fig. 1). TBR originates in the Alborz Mountains and crosses from Mazandaran province. The river basin has a length of roughly 160 km and covering a 4000–2000 km^2 surface. The average slope of its floor within the Area Mountains is 2% and in the plain area 7%. This river basin is a suitable breeding habitat for fishes and sturgeon, carp, trout, pike, whiting fish, spawn, tiddler and whiting fishes, etc. (Lullai, 1999). Also, the vegetation of the margin of TBR is hydrophilic hardwood trees such as Alnus, Populus Alba, and a variety of aquatic plants (Jollodar Naderi et al., 2016). The river basin has a significant effect on water production due to high discharge (1.20 m^3/s). The river's water is used to irrigation of agricultural land (over 46,000 ha), drinking water for Mazandaran province residents, production and industrial units. The beautiful parks nearby of the river basin like the Melal Park and the Ghaem Park, Sahid Zareh forest park, Farah Abad historical complex, etc. and old bridges are considered to be the most important landscape and tourism destinations of the river basin.

2.2. Methods

The research method consisted of evaluation and valuation sections:

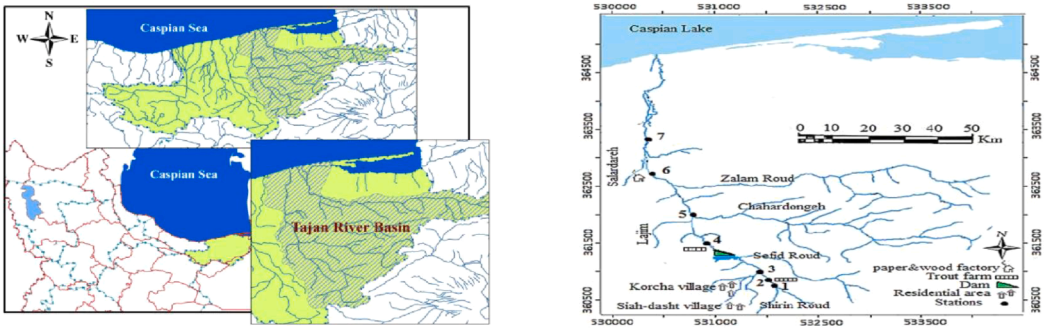
2.2.1. Evaluation

In this study, Multi Criteria Decision Making (MCDM) methods such as Entropy, TOPSIS and SAW use for weighting and prioritizing of Tajan River Basin Ecosystem Services (TRBES). MCDM methods provides a ranking solution to find out the best quantitative solution from a set and it can be said within matrix form as:



A: Mazandaran Providence in Iran

B: Mazandaran Cities



C: Tajan Basin River in Mazandaran province

C: Tajan Basin River

Fig. 1. The location of the Tajan Basin River.

M=		C_1	C_2	C_3	Cn
	A_1	a_{11}	a_{12}	a_{13}	a_{1n}
	A_2	a_{21}	a_{22}	a_{23}	a_{2n}
	A_3	a_{31}	a_{32}	a_{33}	a_{3n}
	A_m	a_{m1}	a_{m2}	a_{m3}	a_{mn}

$W = [W_1\ W_2\ W_3 \ldots\ldots W_n]$

Where A_1, A_2, A_3.....A_m is the available alternatives to be ranked by the decision- maker C_1, C_2, C_3.....C_n is the criteria on which basis the available alternatives are to be ranked. a_{ij} is the performance of value of alternative A_i on the basis of criterion C_j and w_j is weight of the criterion C_j.

2.2.1.1. Entropy. Entropy technique used for calculating weights of the criteria (Ecosystem Services: ES) in evaluation TRBES. Because it is highly reliable for information measurement and provides high accuracy in the determination of the weight of one of the ES. Steps for calculating the weights is as follows (Dashore et al., 2013):

- **Step 1: Creation of decision matrix**

The first step of entropy method is creating of a decision matrix. Therefore, to calculate the weight of the criteria (ES), it must first create the matrix. Because decision matrix is the entropy method input.

$$aij = \begin{bmatrix} a_{11} & a_{12} & a_{1n} \\ a_{21} & a_{22} & a_{2n} \\ a_{m1} & a_{m2} & a_{mn} \end{bmatrix}$$

- **Step 2: Standardization of matrix calculation**

Calculation of weight P_{ij} for the i_{th} alternatives and j_{th} criteria (ES) is based on Eq. (1):

$$Pij = \frac{ajj}{\sum_{i=1}^{m} ai^2 j} \qquad (1 \le i \le m,\ 1 \le j \le n) \tag{1}$$

- **Step 3: Calculate the entropy of each criterion** or the output entropy e_j of the j_{th} criteria (Eqs. (2) and (3)):

$$e_j = -k \sum_{i=1}^{m} (Pij \quad \ln Pij), \qquad (1 \le j \le n) \tag{2}$$

$$k = 1/(\ln m) \tag{3}$$

- **Step 4: Calculate the distance of each criterion from its entropy**

Calculation of variation coefficient of j_{th} factor g_j is as follows (Eq. (4))

$$g_j = [1 - ej], \ (1 \le j \le n) \tag{4}$$

- **Step 5: Calculate the weight of each criterion** (Calculation of weight of the entropy (w_j) (Eq. (5))

$$Wj = \frac{gj}{\sum_{i=1}^{m} gj} \quad (1 \le j \le n) \tag{5}$$

2.2.1.2. TOPSIS. TOPSIS is a technique for order performance by similarity to an ideal solution that it make by Hwang and Yoon (1981). Also, it is one of the well-known MCDM methods. TOPSIS finds the best alternatives using minimizing the distance to the ideal solution and maximizing the distance to the nadir or negative ideal solution. All alternative solutions can rank according to their closeness to the ideal solution. The TOPSIS method consists of the following steps (Vafaei et al., 2018; Hosseini et al., 2024):

- **Step 1: Creation the decision matrix and determine the weight of ES**

Decision matrices expressed as follows (Eq. (6)):

$$D = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \tag{6}$$

Where $i = 1,\ldots, m$ showed the alternatives and $j = 1, \ldots, n$ refers to the attributes; r_{ij} represents the j_{th} attribute related to i_{th} alternative.

- **Step 2: Calculating the normalized decision matrix**

Normalizing the value of decision matrices is as follows (Eq. (7)):

$$nij = \frac{rij}{\sqrt{\sum_{j=1}^{n} rij^2}} \tag{7}$$

Where $j = 1, \ldots, n$; and $i = 1,\ldots, m$.

- **Step 3: Calculating the weighted normalized decision matrix**

Calculating the weighted normalized decision matrix did by Eq. (8):

$$Wij = wij^{*}nij \tag{8}$$

Where w_{ij} represents the weight of the j_{th} attribute related to i_{th} alternative.

- **Step 4: Determination the positive ideal (A^+) and negative ideal solutions (A^-)** (Eqs. (9) and (10))

$$A^{+} = \left\{w_1^{+}, \ldots., w_n^{+}\right\} = \left\{\left(Max\ W_{ij} \quad j \in J\right), \left(Min\ W_{ij}\ j \in J^{'}\right)\right\} \tag{9}$$

$$A^{-} = \left\{w_1^{-}, \ldots., w_n^{-}\right\} = \left\{\left(Min\ W_{ij} \quad j \in J\right), \left(Max\ W_{ij}\ j \in J^{'}\right)\right\} \tag{10}$$

Where J represents the positive factors and J' is the negative factors. Also, the maximum and minimum as the positive ideal and negative ideal when the data is normalized within scale (0, 1) be used. Also, the option 1 used for the positive ideal and 0 used for the negative ideal.

- **Step 5: Calculate the separation measures from the positive ideal solution and the negative ideal solution:**

The distance of all alternatives to the positive ideal (Di^+) and the negative ideal (Di^-) solution calculated using Eqs. (11) and (12):

$$D_i^{+} = \sqrt{\sum_{j=1}^{n} \left(w_{ij} - w_j^{+}\right)^2}, i = 1, \ldots, m \tag{11}$$

$$D_i^{-} = \sqrt{\sum_{j=1}^{n} \left(w_{ij} - w_j^{-}\right)^2}, i = 1, \ldots., m \tag{12}$$

- **Step 6: Rank the preference order or select the alternative closest to 1**

Calculating the relative closeness of each alternative is as follow (Eq. (13)):

$$C_i^{*} = \frac{D_i^{-}}{D_i^{+} + D_i^{-}} \tag{13}$$

Where *Ci* * relies on among 0 and 1 and the higher value corresponds to better performance.

2.2.1.3. SAW. Simple Additive Weighting (SAW) is one of the technics solve multi-attribute decision problems. The technic use for a weighted summation of rating the performance of every alternative on all alternative criteria (ES). The highest score will be the best alternative and recommended (Kaliszewski and Podkopaev, 2016). SAW needs to a process of normalizing the decision matrix (X) to a scale which it can compared with all of the ratings of existing alternatives. Normalizing proses similar to TOPSIS method.

It used Eq. (14) for calculating prioritizing ES. In the Eq (14), W_j is the weight of each criterion and n_{ij} is the value each of the criteria (ES) (Kaliszewski and Podkopaev, 2016).

$$S_i = \sum_{j} n_{ij} \,.\, w_j \tag{14}$$

Finally, R^2 and specialist opinion used for selecting prioritizing suitable methods of the TRBES evaluation (Fig. 2).

2.2.2. Valuation

In the study, Choice Experiment (CE) used the for Tajan River Basin Ecosystem Services (TRBES) valuation (Garcia-Llorente et al., 2012; Khan et al., 2017). The primary step in planning a CE is determining the attributes (ES) and their levels. In the study ecosystem services extracted of article De Groot et al. (2002).

Then for estimating the Willingness to Pay (WTP) for TRBES in Mazandaran province using CH, different levels of four attributes, namely, regulating (it include prevention of flooding; adjusting humidity and air temperature; maintaining the flow of underground water tables; reduction of all types of pollution services), supporting (supporting services contain the providing a suitable habitat for all animal and plant species in the Tajan River (preserving wildlife and biodiversity), provisioning (include services of provision of drinking water for the citizens of Sari city; water supply for the production of agricultural products; water supply for industrial, production and service units; water supply for aquaculture) and cultural services (include provision of natural landscapes; provision of recreational areas and places for citizens) of the Tajan River Basin, plus a price attribute were specified. At each option within the choice set, the respondents choose from the ES and the price level that they want to pay. Price quantity is determined randomly from 239 resident households in Mazandaran province, according to 40 pre-test questionnaires with open-ended questions. Then it asked, "How much are you willing to pay annually to protect ecosystem functions and services of the Tajan River Basin in Mazandaran province?".

The questionnaire was classified in four parts to inform the respondents?

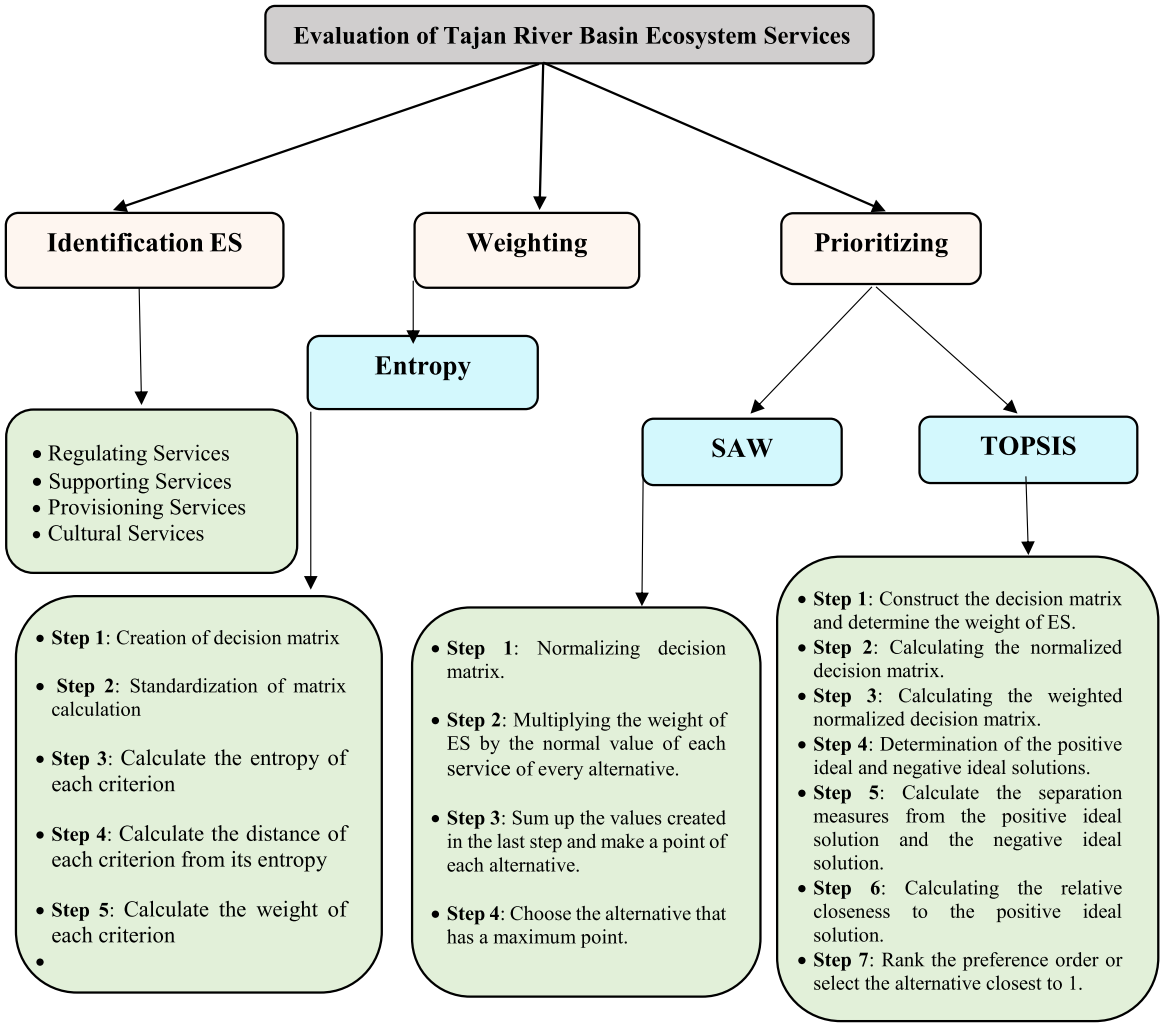


Fig. 2. Methodology steps for evaluation of Tajan river basin ecosystem services.

A: The first part included a short description of Tajan River Basin and it's ES.
B: The second part collecting respondents' demographic or socio-demographic variables (Age, gender, marital status, job, education, household size, household cost and income and other relevant information about respondents).
C: The third part of the questionnaire related to environmental and protection attitudes of respondents (questions were planned based on the Likert scale (1 to 5).

D: The fourth part of the questionnaire related to the choice set for TRBES.

Finding the pre-questionnaire indicated range of Tajan River Basin resident households WTP annually for the protection of TRBES is 2.4 to 7.1 USD. Therefore, three levels are considered for the price attribute contain, 2.4, 4.8 and 7.1. Also, three levels or options for each attribute include the status quo (Option A), destruction situation (Option B) and improvement situations (Option C) were considered.

- The status quo (existing situation): no changes will be made to the status of the Tajan River Basin.
- Improvement status: the existing situation Tajan River Basin will improve 50%.
- Destruction status: the existing situation Tajan River Basin has destroyed 50%.

The attributes and their levels are presented in Table 1 (one of the 7 choice sets of the experiment).

According to the attributes and levels defined, the number of modes available for CE was 3^5 (equals 243 cards). In the study, orthogonal main effect design used for decreasing card number because responsive can't choice many cards. Finally, 7 cards selected using SPSS software. Also, in the study each respondent faces seven sets of choices with four attributes and three levels. In total, for each respondent existed $3 \times 7 = 21$ options (7 chosen sets) to choose. For this purpose, each respondent should

Table 1
Attributes and their levels.

Attributes	Levels		
	A (Destruction)	B (Improvement)	C (The status quo)
Regulating Services	50%	50%	I do not want to make any changes to the existing situation.
Supporting Services	50%	50%	
Provisioning Services	50%	50%	
Cultural Services	50%	50%	
Price (USD)	2.4	7.1	0
Select one options:			

choose one of the three options that they think is more preferable. It should be mentioned that in order for the interviewees not to be limited to only the proposed options, an option with the name the status quo was placed in each card. Then it asked them to choose one of the options A, B and C in each chosen set.

Data Surveyed, collected and completed of 239 resident households within Mazandaran province that they had income. We interviewed to resident households within the various places in Mazandaran province. All questionnaires restricted to residents older than 18-years and having income inclusive different stakeholders, i.e., potential users or beneficiaries, providers, people affected by TRBES. In total, 239 successful in-person interviews were conducted in 2017. Also, in the study for evaluation TRBES, it asked people to rank the foremost services provided by the river basin based on the Likert scale.

2.2.2.1. Model specification. Choice Experiment (CE) proposed by Lancaster's theory of microeconomics firstly (Lancaster, 1996). CE uses McFadden (1974) random utility theory in combination with Lancaster's theory for a determination whether an individual chooses a conservation program or river basin ecosystem between j alternatives (Dias et al., 2015). Pursuant to Lancaster's theory (Lancaster, 1996), any good can be described as a group of attributes and it's levels; in other words being consumer decisions based on the utility of the attributes; it is the level of satisfaction that an individual obtains from a given alternative (Markandya et al., 2001). However, considering the difficulty of entirely defining anything in terms of its characteristics, the random utility model accounts for the unobservable elements by adding an error term (Bateman et al., 2002). The random utility theory assumes that the utility function consists of two components. The definite component v and the random component ε and i of the indexes belong to the respondents Eq. (15):

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{15}$$

In formula 1; U_{ij}: utility function, V_{ij}: related to alternative j and individual i, which represents a factor of observed attributes for good within question (Eq. (16)), bi; coefficients associated with the attributes and an error term.

The modal component consists of three variables y intercept (θ_0), p_j the proposed price per option and β are model variables.

$$V_{ij} = \theta_0 + \alpha p_j + \beta' x_{ij} \tag{16}$$

The index i represents responsive and index j display the selected option. Therefore, vij is the indirectly visible benefit of the i_{th} person from choosing the j_{th} option. The person chooses the option is most desirable to him / her compared to the other options in each selection set. p_{ij} is the possibility of choosing an option (Eq. (17)).

$$p_{ij} = pr(u_{ij} \geq u_{ik}; \forall k \in C) = pr(v_{ij} - v_{ik} \neq \geq \varepsilon_{ik} - \varepsilon_{ij}; \forall k \in C) \tag{17}$$

The logarithmic function of the maximum likelihood is as follows; so d_{ij} is a virtual variable. If option i is selected by person j, it become one and If option i is not selected by person j, it become zero (Eq. (18)).

$$lnL = \sum_i \sum_j d_{ij} ln p_{ij} \tag{18}$$

The probability of choice in Eq. (18) can be written as Eq. (19):

$$prob(i) = \frac{exp^{\mu v i}}{\sum_{i \in c} exp^{\mu v j}} \tag{19}$$

2.2.2.2. Logit models. The probability that i person selected the j option with an explanatory variable is equal to (Eqs. (20) and 21).

$$\Pr\,[Y_i = j\,|x_i] = \frac{\exp(\beta_{0,j} + \beta_{1,j} x_i)}{\sum_{i=1}^{j} exp\,(\beta_{0,1} + \beta_{1,i} x_i)} \quad \text{for } j = 1, \ldots, j \tag{20}$$

And

$$\sum_{j=1}^{i} pr\,[Y_i = j \mid x_i\,] = 1 \tag{21}$$

2.2.2.3. Conditional logit model (CLM). The CLM said the variable behind respondents' choices (Garrod and Willis, 1999). Also, CLM used as a first step in CE method analysis. However, an important implication of the model is that the relative possibility of the two alternatives is unaffected by the introduction or removal of other alternatives (independence from the irrelevant alternatives (IIA) (Luce, 1959). In this sense, this model assumes homogeneity across respondents' preferences.

In the conditional logit model, the explanatory variables remain constant during the options. In this model, the probability that the i_{th} option is selected, it is calculated using Eq. (22):

$$\Pr\,[Y_i = j\,|w_i] = \frac{\exp(\beta_{0,j} + \gamma_1 w_{i,\,j})}{\sum_{l=1}^{j} exp\,(\beta_{0,1} + \gamma_1 w_{i,\,j})} \quad j = 1, \ldots, j \tag{22}$$

In this model, the probability of selection depends on the explanatory variable, which it showed as in Eq. (23):

$$w_i = (w_{i,\,1}\,,\ w_{i,\,2}\,,\ \ldots.,\ w_{i,\,j}) \tag{23}$$

The ratio of the preference of option j to option L calculated by Eq. (24):

$$\varnothing_{j|l}(w_i) = \frac{pr\,[Y_i = j\,|w_i\,]}{pr\,[Y_i = J\,|w_i\,]} = \frac{\exp(\beta_{0,j} + \gamma_l w_{i,\,j})}{\exp(\beta_{0,l} + \gamma_l w_i,\ l)} = \exp(\beta_{0,j} + \beta_{0,l}) + \gamma_l\,(w_{i,\,j} - \gamma_l w_{i,\,l}) \quad l = 1, \ldots, 1 \tag{24}$$

2.2.2.4. Multinomial logit model (MLM). In MLM, individuals' choices depend on individual-specific explanatory variables that have the same value throughout the options. The equation of an MLM for identifying model parameters is as follows (Eqs. 25–28):

$$Pr\left[Y_i = j\,|x_i\right] = \frac{\exp(\beta_{0,j} + \beta_{1,j} x_i)}{\sum_{i=1}^{j} exp\,(\beta_{0,1} + \beta_{1,i} x_i)} \quad j = 1, \ldots, j \tag{25}$$

And

$$\sum_{j=1}^{i} [Y_i = j \mid x_i\,] = 1 \tag{26}$$

It has for $B_j = 0$ and $k = l$:

$$Pr\left[y_i = j\,|x_i\right] = \frac{\exp(\beta_{0,j} + \beta_{1,j} x_i)}{1 + \sum_{j=1}^{J-1} exp\,(\beta_{0,1} + \beta_{1,i} x_i)} \quad j = 1, \ldots, j-1 \tag{27}$$

$$\varnothing_{j|l}(x_i) = \frac{pr\,[Y_i = j\,|x_i\,]}{pr\,[Y_i = J\,|x_i\,]} = \frac{\exp(\beta_{0,j} + \beta_{1,i} x_i)}{\sum_{j=1}^{J-1} exp\,(\beta_{0,l} + \beta_{1,i} x_i)} \quad i = 1, \ldots, J-1 \tag{28}$$

And the logarithm of the probability ratio will be (Eq. (29)):

$$\log \varnothing_{j|l\ (x_i)} = (\beta_{0,j} + \beta_{1,l}) + (\beta_{1,j} + \beta_{1,l}) x_i \quad (29)$$

The two Eqs. (28) and (29) can be shown in a simpler form; the probability of selecting option i, to the probability of not selecting option; it stated in Eq. (30):

$$Odds_i = \frac{\pi_i}{1 - \pi_i} \quad (30)$$

Therefore, the logit probability of option i is equal (Eq. (31)):

$$\mathrm{i} = \mathrm{logit}\ (\pi_\mathrm{i}) = \log \frac{\pi_\mathrm{i}}{1 - \pi_\mathrm{i}} \quad (31)$$

Thus, MLM seems as the most flexible model to estimate random utility models. The model accounts for heterogeneity among individuals, incorporates correlation in the utility among choices and allows for random preference variations between respondents (McFadden and Train, 2000).

One of the important requirements for specification CLM is following the independence from the irrelevant alternatives (IIA) by using the Hausman-McFadden statistic in 1984. Hausman and McFadden test statistics were calculated with Eq. (32):

$$T = (\widehat{\beta_r} - \widehat{\beta})' (\widehat{V_r} - \widehat{V})^{-1} (\widehat{\beta_r} - \widehat{\beta}) \sim x^2\ (m) \quad (32)$$

$$\begin{cases} H_0 : T = 0 \\ H_1 : T \neq 0 \end{cases}$$

Table 2
Calculated weight, scores and priority of TRBES using the Entropy, SAW and TOPSIS methods.

Services	Weight	Score (Max weight)		Priority	
	Entropy	SAW	TOPSIS	SAW	TOPSIS
Regulating	0.2488	0.4337	0.1276	3	3
Supporting	0.2511	0.5721	0.1723	1	1
Provisioning	0.2500	0.4756	0.1425	2	2
Cultural	0.2501	0.3512	0.1088	4	4

After estimating the model, willingness to pay (WTP) can be estimated for each of the features and levels.

Finally, willingness to pay calculated of Eq. (33) (Hensher et al., 2005):

$$WTP_{attribute} = -(\beta_{attribute} / \beta_{price}) \quad (33)$$

CLM and MLM models used to determine willingness to pay resident households in Mazandaran province (respondents) for Tajan River Basin ecosystem services (TRBES). Socio-demographic variables set in CLM and MLM models, as were cross effects among attributes and statements regarding different TRBES in Mazandaran province. You could observe more information about the models in Hensher et al. (2005); Louviere et al. (2000), or Train (2009) articles.

In the study, Excel, Spss16 and STATA software used for questionnaires data statistical analysis and estimating households' WTP for

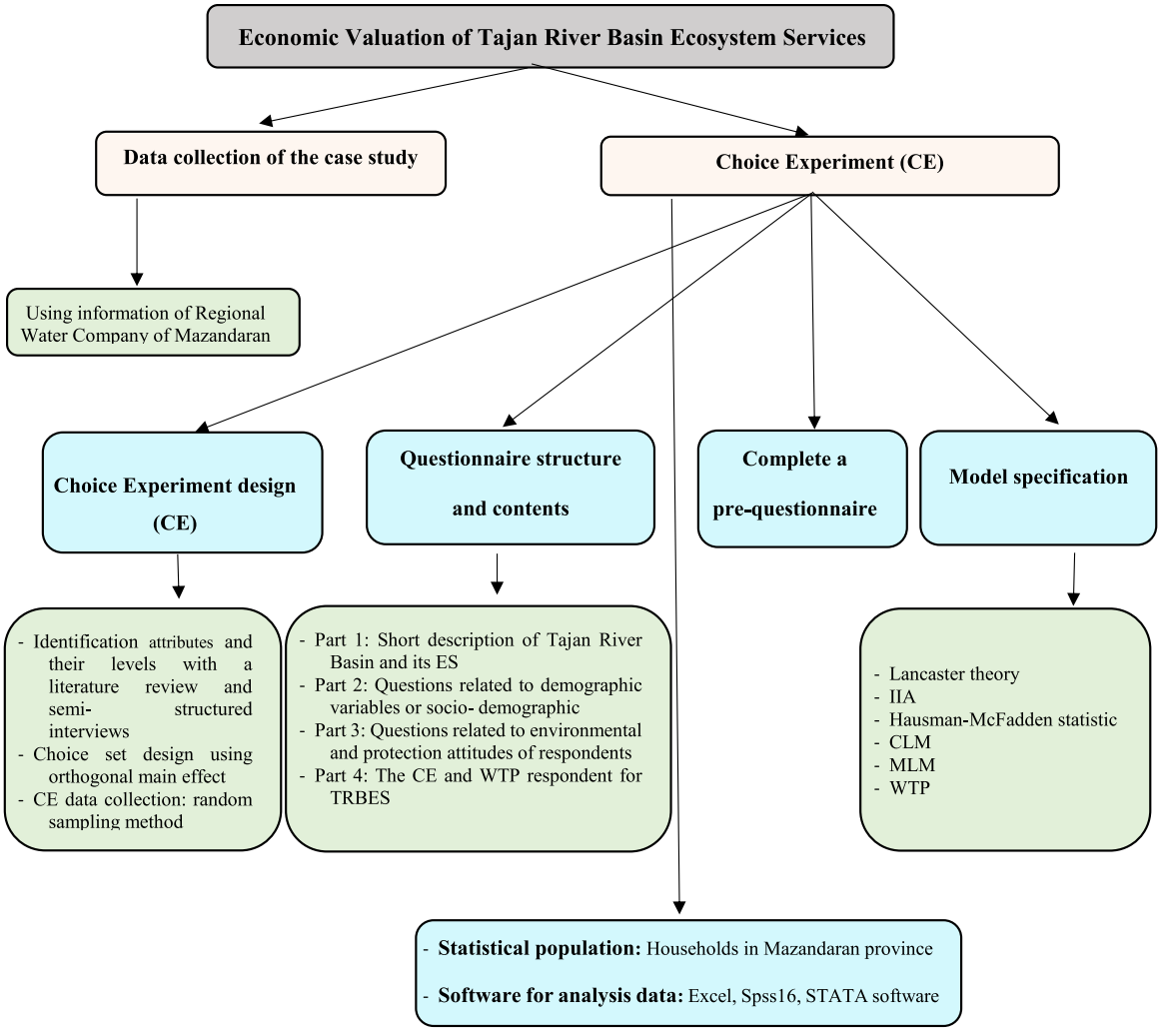


Fig. 3. Methodology steps for economic valuation of Tajan river basin ecosystem services.

TRBES. Methodology steps for economic valuation of Tajan river basin ecosystem services shown in Fig. 3.

3. Results

The results showed in three parts. The first part said the weight and priority of the Tajan River Basin Ecosystem Services (TRBES) for them evaluation. The second part investigated the selection of the best method for the prioritization of the TRBES. The final part contains the result of economic valuation of the TRBES.

3.1. Evaluation

3.1.1. Weighting and prioritization of Tajan River Basin eEcosystem Services (TRBES)

MCDM model findings stated in Tables 2. The weighting Tajan River Basin ecosystem services evaluation with Entropy methods showed that supporting services get max weight (0.2511) between other services (Table 2). Also, the results of the prioritization TRBES evaluation with SAW and TOPSIS methods showed that supporting (0.2511), provisioning, regulating (0.2488) and cultural services (0.2501) get first to fourth priority based on weight respectively (Table 2).

3.1.2. Selection of the suitable model for the prioritization of Tajan river Basin ecosystem services

Findings of the comparison of prioritization methods of TRBES evaluation indicated that the TOPSIS model with an R^2= 0.97 is better than SAW model with R^2= 0.87.

Finally, the results of the percentage of the importance of each TRBES in Mazandaran province based on the frequency of the highest score (according to the Likert scale: score 5) extracted from data from 239 resident households. The results showed that supporting (39%), provisioning (27%), regulating (25%) and cultural (9%) services are the most important services for the citizens in Mazandaran province, respectively (Fig. 4).

3.2. Valuation

3.2.1. Socio-demographic variables of respondents

Socio-demographic variables of 239 respondents (data obtained from the questionnaire) showed that respondents were gender differentiation (59.83% male and 40.17% female), marital status (82.85% married and 17.15% single) (see Table 3). Also, the employment situation, respondents were divided into two categories employer (70.29%) and non-employer (29.71%). Besides, 82.01% of resident households (respondents) in Mazandaran province had high education and 17.99% of them had low education.

Table 3
Definition's statistics of socio-demographic variable of respondents.

Variables	Description	Percent	Number
Gender	Man	59.83	143
	Female	40.17	96
Marital status	Single	17.15	41
	Married	82.85	198
Job	Employee	29.71	71
	Non-employee	70.29	168

Table 4
Definition's statistics of variable and respondents.

Variable	Mean	Min	Max	SD	CV
Age (years)	38	18	68	11.58	3.31
Household dimension	3.73	1	7	1.17	3.16
Household income (USD)	892.86	47.62	3333.33	466.74	190
Household cost (USD)	529.76	23.81	1428.57	28.94	1.80

SD: Significant deviation CV: Coefficient of variation.

The results of the survey of the respondent's socio-demographic variables showed that the mean age of the resident households was 38 years old (middle-aged). Based on age range of the respondents, 34.73% belong to the age category of 30–40 years, 40–50 years (20.08%), over 50 years (15.9%) and under 20 years (1.26%). Also, the mean household size with dependent children was 3.73 person, the highest number of members (7 persons) and the lowest (one person). Also, the average personal household income and cost were 892.86 and 529.76 USD per month respectively (Table 4).

3.2.2. Investigating the environmental and protective attitude of respondents

The result indicated that 75.8% of the respondents had a positive and 15.8% a negative attitude to the environment, and 8.4% of respondents expressing indifference to the river basin environment (Table 5).

Results of investigating the respondent's attitude in protecting the

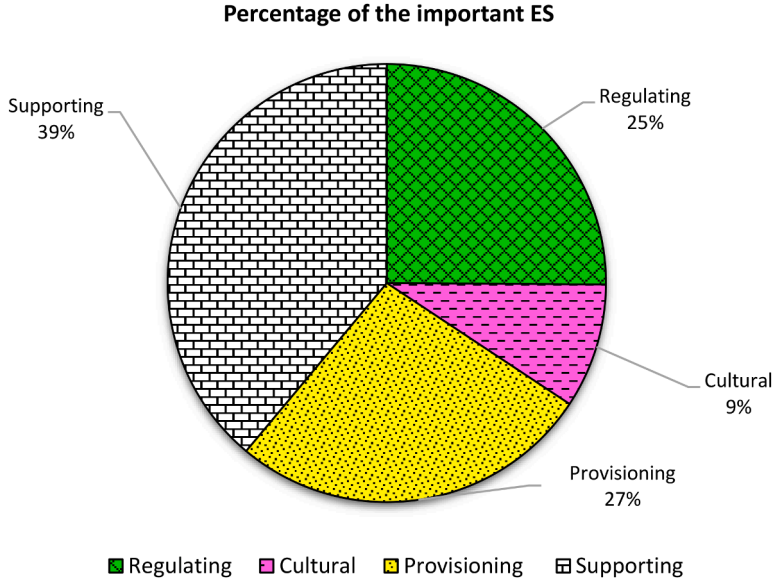


Fig. 4. Percentage of the importance of each of the TRBES.

Table 5
Respondents' environmental attitudes.

Environmental Statements	Completely disagree	Disagree	Indifferent	Agree	Strongly agree
The environment has no value for me.	147	88	3	1	0
I don't have willing to pay for environmental protection.	49	120	12	43	15
I do not have the financial potential for environmental protection.	43	88	29	61	28
The environment must be used for supporting country food.	26	86	48	55	24
The organizations and government agencies did suitable measures proceedings to conserve the environment.	24	55	48	71	44
The protecting of environment and banning environmentally damaging and polluting activities have an effect in principle 50 of the Iranian constitution is good proceedings.	5	11	74	91	58
Environmental services are well known to me and I can mention a few of them.	6	26	24	110	73
The TRBES are valuable to me.	12	15	8	106	98
Expanding job creation plans are useful for the environment.	87	103	21	24	4
Educating people about environmental issues is effective in protecting the environment.	0	5	8	102	124
Creating and expanding NGOs can be helpful to protect the environment.	1	3	9	104	122
Lack of attention to environmental issues in construction projects is a threat to the country's environment.	1	5	6	92	135
Insufficient knowledge of people from the environment will lead to its destruction.	1	3	4	88	143
The encroachment to the lands around the Tajan River Basin is a threat to the river.	0	5	5	84	145
I would like to pay some money to protect the Tajan River Basin.	18	24	16	86	95
Protecting the Tajan River Basin for using future generations is essential (Bequest value).	1	3	12	74	149
The existence of the Tajan River Basin is important to me even I use it or not use it (Existence value).	0	2	17	91	129
The existence of the Tajan River Basin is important to me so that I can benefit from it in the feature years (Option value).	1	4	17	92	125

Table 6
Respondents' protective attitudes.

Questions	Little	Very little	Medium	Much	Very much
How much have you increased your desire to protect the Tajan River Basin with the information given to you?	40	57	61	81	0
How much informing people about river basin ecosystem services can be effective in protecting this river?	1	9	45	117	67
How much financial ability increases your desire to protect the TRBES?	1	2	29	115	92
Percent (%)	5.9	9.5	18.8	43.7	22.2

Table 7
Estimation of the ecosystem services of Tajan River Basin value using CLM.

Attribute	Coef	Std. Err.	Z	$p>\|z\|$	dy/dx
Regulating	0.149	0.0651	2.29	0.022**	0.035
Supporting	0.359	0.0657	5.48	0.000***	0.084
Provisioning	0.134	0.0650	2.07	0.038**	0.031
Cultural	0.142	0.0651	2.19	0.029**	0.033
Price	0.136×10^4	0.473×105	2.88-	0.004***	$- 0.319 \times 10^5$
LR chi^2 (5): 386.71 $N = 5019$ Prob> chi^2:0.000 Log likelihood R^2=−621.67					

Coef: Coefficient; Std. Err: standard error; dy/dx: Marginal effect; S.L: Significance level; St: Significance at the 10%=*, 5% =** and 1%=*** levels.

Tajan River Basin (TRB) listed in Table 6. The results of the study revealed that 65.8% of respondents stated that knowledge about TRBES increases their WTP for their conserve.

3.2.3. Estimation of Conditional Logit Model (CLM)

Results of the CLM for illustrating Tajan River Basin Ecosystem Services (TREBS) value showed in Table 7.

The results stated that according to chi-square test for a survey of IIA (χ^2 =−371/38), the null hypothesis (H_0) was based on the lack of a systematic relationship between options or IIA confirmed in choosing a set. Also, according to the findings, LR chi^2 is estimated to be 386.71 that it indicated the CLM was significant at the 1% level. This interpretation confirms model results (see Table 7). Among the attributes, an attribute

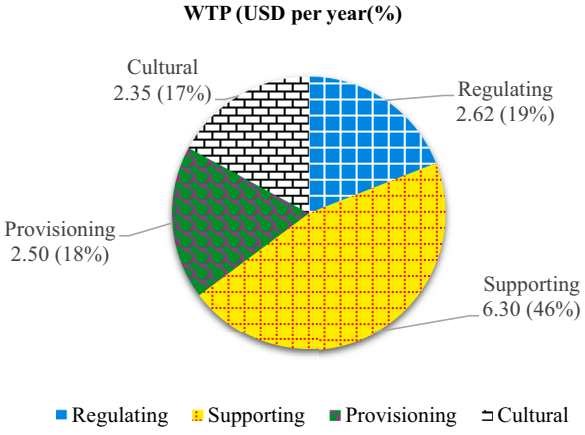


Fig. 5. Willingness to Pay and implied rankings for TRBES.

of the supporting and the price on the level of 1% and regulating, provisioning, cultural on the level of 5% was significant.

According to the results presented in Table 7, the sign of all selected attributes was positive and they had a significant effect on willingness to pay protection of Tajan River Basin (TRB) in Mazandaran province of Iran. But sign coefficient price was negative and this was perfectly consistent with the theory. It means that with increasing prices, the likelihood of chosen options decreases by respondents. In this estimation, the coefficients of all ES attributes of the TRB are positive and they have a significant effect on the WTP of resident households. The result revealed resident households are willing to pay to change and improve the status quo (existing situation) TRB and increasing their utility. The marginal effect of the regulating service attribute 0.035, it means that with other conditions remaining and a unit increase in regulating services, 0.035 units of marginal utility of respondents or WTP these respondents to use of the ES of the TRB area increases.

According to the results showed in Table 7, the marginal effect of supporting service was 0.084. In other words, by improving one unit of supporting services and other conditions remain constant, the marginal utility of the respondents or their WTP is increased to 8.4%. Also, the marginal effect of the negative price variable is estimated 0.319×10^{-5}. It states that with one-unit increase in the price if other conditions remain constant, 0.319×10^{-5} units of the marginal utility or

Table 8
MLM estimation despite the interactions of socio-demographic variables.

Attributes × Variables	Coef	St. dev	Z statistic	S.L ($P > Z$)
Regulating × Age	0.004	0.007	0.54	0.58
Regulating × Gender	0.209	0.145	1.44	0.151
Regulating × Marital Status	−0.654	0.211	−3.09	0.002***
Regulating × Job	0.02	0.034	0.86	0.389
Regulating × Education	0.005	0.016	0.33	0.739
Regulating × Family size	0.111	0.062	−1.79	0.073*
Regulating × Cost	0.211×10^{-6}	0.714×10^{-7}	−2.96	0.003**
Regulating × Income	0.820×10^{-7}	0.475×10^{-7}	1.73	0.084*
Supporting × Age	0.001	0.007	0.25	0.805
Supporting × Gender	−0.275	0.145	−1.90	0.058**
Supporting × Marital Status	0.076	0.211	0.36	0.718
Supporting × Job	−0.021	0.034	−0.62	0.532
Supporting × Education	−0.018	0.016	−1.18	0.239
Supporting × Family size	0.014	0.062	0.24	0.809
Supporting × Cost	0.134×10^{-6}	0.712×10^{-7}	1.89	0.059**
Supporting × Income	-0.102×10^{-7}	0.475×10^{-7}	−2.15	0.032**
Provisioning × Age	−0.009	0.007	1.29	0.199
Provisioning × Gender	0.019	0.145	0.13	0.893
Provisioning × Marital Status	0.364	0.212	1.72	0.086*
Provisioning × Job	−0.023	0.034	−0.68	0.496
Provisioning × Education	−0.036	0.016	2.29	0.022**
Provisioning × Family size	0.050	0.062	0.82	0.413
Provisioning × Cost	-0.734×10^{-7}	0.713×10^{-7}	−1.03	0.303
Provisioning × Income	-0.230×10^{-7}	0.475×10^{-7}	−0.48	0.628
Cultural × Age	−0.010	0.007	−1.33	0.182
Cultural × Gender	0.051	0.145	0.36	0.721
Cultural × Marital Status	0.054	0.211	0.26	0.795
Cultural × Job	0.023	0.034	0.69	0.489
Cultural × Education	−0.025	0.016	−1.59	0.111
Cultural × Family size	0.015	0.062	0.24	0.808
Cultural × Cost	0.129×10^{-6}	0.713×10^{-7}	1.81	0.070*
Cultural × Income	0.359×10^{-8}	0.475×10^{-5}	0.75	0.451
Intercept	−1.314	0.108	−12.13	0.000***
$N = 5019$ Pseudo R^2=0.0733 Prob> chi^2: 0.000 LR chi^2 (37): 468.12				

S.L: Significance level, St: Significance at the 10%=*, 5%=** and 1%=*** levels.

willingness of respondents to pay for the TRBES in the Mazandaran province will decrease.

3.2.4. Survey of respondent's WTP for TRBES

Fig. 5 report the willingness to pay for the attributes by CLM. According the results, resident households in Mazandaran province had more WTP for supporting, regulating, provisioning and cultural services, respectively. Also, each of the respondents is willing to pay 13.77 USD per year (each household per year) to improve the TRBES in Mazandaran province (Fig. 5).

3.2.5. The investigation interactions of socio-demographic variables on WTP

MLM was used to survey the indirect effect of socio-demographic variables on the rate of WTP of Mazandaran province residents' (interactions). The indirect effect of the socio-demographic variables such as age, gender, marital status, occupation, education, household size, cost and income on the WTP for determining the value of TRBES showed in Table 8.

4. Discussion and conclusions

Evaluations of Ecosystem Services (ES) river basin used for management and designing the river basin (Pires, 2004). In the study, the results of weighting the Tajan River Basin Eosystem Services (TRBES) evaluating using entropy technique showed that the weight of supporting services is more than other services. Chaikaew et al. (2016) within the Suwannee River Basin and Zawadzka et al. (2019) in natural ecosystems concluded that river supporting services is important rivers services. Also, prioritization methods results revealed that the supporting services obtained the first priority compared to other services in the TRBES evaluation. Sieber and Pons (2015) used MCDM for prioritization and evaluation of China Urban River Basin Ecosystem Services in Singapore city. The study's results showed that supporting services had been the most important from the perspective of riverside residents.

Also, comparing the outcome of the prioritization of the Tajan River Basin Ecosystem Services using R^2 revealed that TOPSIS results compared with SAW closer to reality. Barrena et al. (2014) and Hosseini et al. (2021) studies stated that among the MCDM models for the assessment of natural ecosystem services, the TOPSIS model provides more suitable results.

According to the mathematical equation based on random utility, econometric models and CLM can estimate the factors affecting the people's WTP for environmental attributes (7 and 8 Tables). According to the results of Table 7 all variables such as regulating, supporting, provisioning and cultural and price had the expected coefficients and significant at the 1% and 5%.

Price variable had a negative coefficient, and it was statistically significant. It means, increasing the price reduces the likelihood of acceptance for payment. Also, it can be observed that the coefficients of variables related to TRBES in Mazandaran province are statistically significant, which indicates an increased likelihood of WTP Mazandaran province residents by improving TRBES.

Results indicate, resident households in Mazandaran province are willing to pay an average of 13.77 USD per year for improving the status of supporting services (conservation of aquatic and plant species). Also, the findings showed that the WTP respondents for the protection and improvement of supporting services were the first priority and the regulating, provisioning and cultural services occupied the next positions. They are willing to pay more for supporting services Tajan River Basin (6.30 USD per year). That's means for respondents' supporting services and their improvement is the first priority. Because Tajan River Basin was one of the natural and reproductive habitats for fishes and sturgeons (Lullai, 1999) and suitable habitat for hydrophilic hardwoods trees such as Alnus, Populus Alba and a variety of aquatic plants (Jollodar Naderi et al., 2016). Also, Tajan River passes through the city. Therefore, it is an inner-city river that there are many aquaculture places and agricultural lands on the around the river, which has done attract many tourists in that area.

In this regard, Kunwar et al. (2020) used the CE method for conducting public preference for Danda river restoration using data analysis from 637 respondents. Respondents were willing to pay up to 1.63 USD /year to move away from the status quo level of services in the Danda River. Also, Barbier (2016) and Zander and Straton (2010) findings on the river ecosystem services in Australians showed that many respondents preferred healthy coastal and river ecosystem.

As well as respondents are willing to pay for improving as regulating, provisioning and cultural TRBES 2.62, 2.50 and 2.35 USD per year respectively. These attributes are in the second, third and fourth priority for respondents respectively. The results offered that choice experiment method can used for recognizing the importance of the underlying ecosystem services using calculating WTP. The results studies of Andreopoulos et al. (2015) for river Aoos basin within Greece, Lavelle et al. (2014) in Orinoco River Basin of Colombia, Ahtiainen et al. (2015) at Finland; Perni and Martinez-Paz (2017) in Hondo wetland in Spain and Lan et al. (2020) at the valuation of the marine ecosystem services

surrounding selected offshore islands of Vietnam showed that supporting service is an important ecosystem services River for residents near the river.

Regarding the value of TRBES in Mazandaran province (13.77 USD per year), it is suggested that related organizations such as forests, rangelands and watershed management, Mazandaran province of natural resources department, water department, the Jahad agricultural organization will do the including as age, gender, marital status, job, education, household size, household cost and income on the WTP of Mazandaran province residents for Tajan River Basin natural ecosystem services.

The finding revealed the indirect effect of income on the regulating service Tajan River Basin was positive and significant. In other words, with the increase in the income of Mazandaran province residents, their WTP to improve the regulating service of the Tajan River Basin increases. Also, the indirect effect of cost, age and household size variables on the regulating service Tajan River Basin were negative and significant. The result indicates that increasing the age and household size reduces the tendency to participate in river regulating service maintenance programs. In fact, larger households are less concerned about the state of the environment and its improvement, and prefer the status quo to conservation programs.

As well as, the indirect effect of the cost variable on supporting service was positive and significant and variables of gender, education, job and income were negative and significant. The result indicated that the cost of living increases, the tendency of citizens to protect supporting services did not decreased, and environmental issues and river ecosystem services was very important to them.

The indirect effect of variable marital status and education on positive provisioning service was positive and significant. In this study, respondents with higher education are more WTP for improving TRBES, therefore, recommended to public health awareness to consumers of aquatic products by programs such as the broadcasting provincial newspapers and relevant organizations be increased. Also, the indirect effect of the cost variable on the cultural service was positive and meaningful. The results showed that the indirect effect of the cost variable on regulating and provisioning services was negative and significant. The result indicates that costs have a negative effect on the Mazandaran province resident's utility to use the Tajan River Basin regulating and provisioning services and willingness to use these services should decrease as the cost of living increases. The results of this section are similar to studies finding Garcia-Llorente et al. (2012); Mann et al. (2012); Mandal et al. (2020) and Pullanikkatil et al. (2020). They obtained a positive and significant effect between river environmental attributes within a river recovery plan.

According to the results of socio-demographic variables effect on the WTP for Tajan River Basin Eosystem Services (TRBES) using MLM, it suggested to more attention to them in environmental policies of rivers. Also, the results of the survey role and importance of TRBES in Mazandaran province residents using CE showed that the point of view respondent supporting, regulating, provisioning and cultural services are among the important services of the Tajan River Basin respectively. The results revealed that supporting services took the first priority of River Basin services using CE and MCDM methods. Therefore, for protection habitat services suggested that the interests and attitudes of respondents be considered for the protection and development of river basin services. Also, it is suggested to identify the beneficiaries of Tajan river ecosystem services and to investigate their attitudes and willingness to pay for river ecosystem services in future researches. The research findings illustrated the CE and MCDM methods can use for making suitable decisions for river basin management. Therefore, it suggested that the results of the study considered as a pattern for designers and decision-makers of river engineering and landscape of river basin margins.

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Declaration of competing interest

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Data availability

The data sets created and / or analyzed during the current study are not publicly available for some reason, but are available upon request from the author.

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