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A proposed framework for economic valuation and assessment of damages cost to national wetlands ecosystem services using the benefit-transfer approach

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ABSTRACT

Wetland valuation is a policy tool available to environmental planners and policy-makers to justify the general costs of wetland preservation activities. Because there is no integrated procedure for valuing goods and services in the country, this article is the first attempt in Iran to provide a comprehensive yet simple and practical framework on how to value ecosystem goods and services. Estimating the cost of damage to ecosystem services can be effective in preventing further damage to wetland ecosystems. The study aims to propose a framework for estimating the environmental costs of development activities and estimating the damage to the values of the wetland ecosystem services within the direct and indirect effects of development activities. The benefit transfer method was used to estimate the values of ecosystem services of each land use/land cover (LULC) class and damage costs to ecosystem goods and services provided by wetlands. Using the Ecosystem Services Valuation Database (ESVD), the coefficients of the average values of ecosystem services for the country over a period of one year were estimated using the equation for adjusting the overall price levels. The mean values of ecosystem services per hectare of coastal and inland wetlands were updated based on the price levels in 2021. Then the corresponding values were adjusted for Iran. The sum of the “means” of the adjusted ecosystem service values per hectare for the Iranian coastal mangrove wetland ecosystems and inland wetland ecosystems are estimated to be 67,665 USD and 42,171 USD, respectively.

1. Introduction

It is essential to determine the economic value of wetlands when developing sustainable wetland development plans and market-based ecological protection strategies (Thapa et al., 2020). Wetlands provide a broad and diverse range of ecosystem services both for local and global communities. Local communities are interested in investing in the protection and restoration of the future consumptive values of wetlands (Baral et al., 2016).Wetlands provide ecosystem services and therefore have significant economic values. Ecosystem services (ES) are natural processes and functions essential for human well-being and livelihood (Mueller et al., 2016; Sannigrahi et al., 2021; Wondie, 2018; Li et al., 2020). Humans benefit from ecosystems, and the destruction of these natural resources, directly and indirectly, affects their well-being (Assessment 2005). Ignoring the value of wetland ecosystem services can lead to reduced protection of aquatic ecosystems followed by a decreased supply of ecosystem goods and services offered from wetlands that people benefit from directly or indirectly (Barbier, 2013; Sarkheil et al., 2021). Applying economic valuation methods in real policy making is still a rare phenomenon. Analyzing the valuation studies shows in which sectors the influence of economic valuation on decision-making needs to be strengthened in the future and what role it will play in better management of resources (Merriman and Murata, 2016). Population growth, human activities, and the execution of inappropriate development projects resulted in damages to the valuable wetland ecosystems. The consequences of such damages will lead to irreversible changes in the long term. These changes will reduce the value of ecosystem services. These vital wetland ecosystems can be preserved and restored by introducing an appropriate economic valuation method and optimal protection strategies for them (Salehipour et al., 2015). Valuation of the ecosystem services provided by wetlands is important for decision-makers and policy-makers (Zhou et al., 2020; Pasupalati et al., 2017). In addition to facilitating the decision-making process easier, valuation also provides the basic information for wetland management and its proper use (Paudal, 2009).

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1.1. Theoretical foundations

1.1.1. Identification and classification of wetland ecosystem goods and services based on the millennium ecosystem assessment classification

A checklist of ecosystem services defined in the Millennium Ecosystem Assessment approach is divided into the following four categories: provisioning, regulating, cultural, and supporting services.

Provisioning services: Providing raw materials extracted or collected from the wetlands.

Regulating services: Maintaining the desirable environmental conditions for human communities.

Cultural services: Strengthening the human communities

Supporting services: Preserving the integrity, functioning, and resilience of the ecosystem as well as providing what is necessary for the production of all the ecosystem services (RRC-EA 2020).

Based on the Millennium Ecosystem Assessment, ecosystem goods and services are classified into the following four main categories:

- Life support services: These are necessary for the other services and include soil formation, primary production, nutrient cycling, water cycle, and habitat provision.
- Regulating services: These services are provided by regulating ecosystem processes such as gas regulation, regulation of local and global climate, water regulation, erosion control, disturbance regulation, and flood control, biological control (including regulation of pests), and waste treatment and water purification.
- Provisioning services: These include the products obtained from the ecosystem, including food, water, timber, fiber, agricultural products, and genetic resources.
- Cultural and esthetic services: These are non-material services that people receive from nature and ecosystems and include cultural heritage, spiritual, scientific, research, educational and recreational benefits (Zarandian, 2015).

One of Iran's most important and key environmental issues is the degradation of the wetland ecosystem caused by a wide range of human activities and interventions along with natural factors both within and outside the wetlands. A list of key ecosystem services related to each natural ecosystem should be counted, assessed, and valued separately to assess the damage cost to ecosystem services and the economic valuation of ecosystem services. The purpose of this classification is to provide a framework for evaluating the impacts on ecosystem services. In this way, for each ecosystem, several services are considered a basis for valuation, and other services can be included. Most ecosystem services are common in inland and coastal wetlands, but some services, such as coastal protection against storms and tidal waves, are specific to coastal wetlands. Table 1 demonstrates ecosystem services for inland and coastal wetlands. In the column on the examples of different types of ecosystem services, the services that are specific to coastal wetlands are written and specified.

1.1.2. Wetland ecosystem economic valuation methods

Four approaches are commonly used for ecosystem valuation, which may use different methods. These four approaches include: Market-based approach (which includes market pricing and production function methods), revealed preference approach (which includes avoided cost, replacement cost, travel cost, and hedonic pricing methods), stated preference approach (which includes contingent choice and conjoint analysis) and benefit transfer approach (Stelk and Christie, 2014). The following describes each of the methods:

■ ***Market-Based approach***

Market-based techniques include the market price and the productivity methods (Stelk and Christie, 2014)

Market Price Method

This is frequently used for ecosystem goods that are traded in commercial markets (Mehvar et al., 2018). The main objective is to measure the sum of economic surplus (producer and consumer) obtained based on changes in a final good or service (Stelk and Christie, 2014).

Productivity Method

The productivity method can be utilized to estimate the economic value of the ecosystem benefits used in the production chain (the inputs) for commercially sold goods (the outputs). When natural resources are a production component, any changes in their quality or quantity will change the production costs. This can affect the price and quantity of the final product (Stelk and Christie, 2014).

■ ***Revealed Preference approaches***

These techniques include replacement/substitute cost, avoided cost, hedonic pricing, and travel cost methods (Stelk and Christie, 2014).

Avoided Cost and Substitution / Replacement Cost Methods

Replacement cost: This is determined by how much people are willing to pay to avoid losses/damages. The cost of replacing and/or Substitutioning services, or the cost of paying for replacement services, performs the same functions and provides the same benefits (Mehvar et al., 2018).

Travel Cost Method

The travel cost method estimates the value of an ecosystem that provides recreational benefits for humans. This value is obtained from people's time and travel costs on visiting a site (Stelk and Christie, 2014).

Hedonic Pricing Method

The hedonic pricing method mostly reflects changes in housing or land prices, reflecting the value of the adjacent environmental attributes. This method can be used for estimating the economic costs or benefits attributed to noise, water pollution, air pollution, landscapes of or adjacent to recreational sites (Stelk and Christie, 2014). It is commonly used to estimate the value of ecosystem services involved in providing facilities and welfare. The value of welfare services provided by ecosystems is frequently indicated by the price of an asset (Mehvar et al., 2018). In other words, it is the estimated impact of environmental attributes on market goods prices (de Groot et al., 2020).

■ ***Stated Preference approaches***

Stated preference techniques ask people to respond to hypothetical positions, and their responses are used for inferring monetary value based on demand (Stelk and Christie, 2014).

Contingent Valuation Method

This is the most commonly used method for determining consumptive and non-consumptive values, and it is based on a survey in which people are asked if they are willing to pay (WTP) for an ecosystem service (Mehvar et al., 2018).

Contingent choice Method

WTP is based on the selection from among the various hypothetical scenarios of ecosystem status (Mehvar et al., 2018).

■ ***Benefit Transfer approach***

The value of ecosystem services at the policy site is estimated using the available data and information from the various previous studies (Mehvar et al., 2018; de Groot et al., 2020) for similar usage.

2. Methodology

Although many valuation approaches have been proposed, most of them are intended to improve our understanding of ecosystem services with complex and diverse economic and social characteristics. This study reviewed and studied five major guidelines for valuing wetland ecosystem services and articles on valuation and estimating the cost of damages inflicted on wetland ecosystem services. It attempted to develop a pattern model for integrated economic valuation and damages estimation to ecosystems. Following a comparative review of the selected articles that have been published and their instructions related to the topic of this research, the step-by-step process of economic valuation of ecosystem services and estimation of the damage cost inflicted

Table 1
Ecosystem services of inland and coastal wetlands (Merriman and Murata, 2016; Environmental Management Division, 2019; Barbier, 2013).

Example	Role of wetland structure/function	Type of ecosystem services
Food production	Production of fish, fruits, grains	Provisioning
Freshwater supply	Water storage, supply of drinking water	
Fiber, fuel, and other raw materials	Production of timber, fuel wood, peat, fodder	
Genetic resources	Genes for resistance to plant pathogens	
Ornamental species (This service is specific to coastal wetland)	(e.g., Aquarium fish)	
Air quality regulation	e.g., trapping of dust particles	Regulating
Climate regulation	Regulation of greenhouse gasses, temperature, precipitation, and other climatic processes	
Hydrological regulation	Groundwater recharge, / drainage, regulation, and storage of water for agriculture or industry	
Pollution control and detoxification	Removal of nutrients and contaminants	
Erosion control	Preserving soil and preventing structural change (coastal erosion, etc.)	
Disturbance and natural hazard regulation (This service is specific to coastal wetland)	Flood control, protection against storm (Weakening or scattering of waves, the barrier against the wind)	
Biological control	Pest control and pollination	
Cultural heritage	Sense of place and belonging	Cultural
Spiritual and inspiration	Personal feelings and well-being (many cultures place spiritual values on the wetland and have specific religious practices associated with it).	
Recreational	Opportunities for tourism and recreational activities	
Aesthetics	esthetic features of wetlands, appreciation of natural features	
Educational	Opportunities for formal and non-formal education	
Biodiversity and nursery	Habitat for Established species or transient species	Supporting
Soil formation	Sediment retention and accumulation of organic matter	
Nutrient cycle	Storage, retrieval, processing, and acquisition of nutrients	

on wetland ecosystems as a result of development activities is presented in six stages. The benefit transfer method was used in this research because it seems suitable for developing countries such as Iran that face time and budget constraints in valuation studies. Fig. 1 depicts the steps of the proposed conceptual framework.

3. Results

Step 1: Identify and classify the types of ecosystem goods and services related to wetland ecosystem influenced by development activities with emphasis on comparing the current and situation and predicting future impact trends related to the types of land- use surrounding site and ecosystems within the environmental impact scope of the development activities using the DPSIR model (Identifying natural and human impacts on ES and assessing the status and vulnerability of ecosystem services and changing trend of ecosystem services)

Wetlands are affected by human activities and natural events:

Wetland ecosystem services change in response to changes in land use. Therefore, it is important and crucial to study and predict the influence of both natural impacts (climate change) and human interventions on wetland ecosystem services (Langan et al., 2019). Among the most important direct human driving forces affecting wetlands are land-use changes, the increasing emission of pollutants, the discharge of sewage and waste into wetlands, and the over-exploitation of wetland resources. Other direct driving forces include effective natural events, including droughts and climate change (such as seawater fluctuations). Population growth is among the most important indirect driving forces. Some effects are common to inland and coastal wetlands, and some are exclusive to coastal wetlands (e.g., the consequences of seawater fluctuations on wetland ecosystem services). Therefore, the effects on ecosystem services will be different. Accordingly, it is necessary to identify the type of wetland ecosystem in terms of being inland or coastal and the status of wetlands in Ramsar Wetlands or Montreux Records. In the ecosystem services approach, The DPSIR model is suggested to understand the stakeholders better. The DPSIR model is used to determine management strategies against the vulnerability of ecosystem services. DPSIR is a useful tool for policies, plans, and programs to follow effective measures (Serrano, 2012). The inclusion of "Impact on Ecosystem Services" at the core of the DPSIR has been proposed for ecosystem-based management, which has led to the formation of the DPSIR framework. DPSER has the flexibility and structural advantages of DPSIR and the capability to set the essential metrics for each level of DPSER, e.g., ecosystem service trade-offs (Mercado-Garcia et al., 2018). The ecosystem service approach provides a basis for evaluating the benefits of ecosystems and estimating their values (ten Brink et al., 2011bib41). The most important valuation methods proposed for different types of ecosystem services for coastal and inland wetlands of Iran are listed in Table 2. In the column on the examples of different types of ecosystem services, the services that are specific to coastal wetlands are written and specified. Considering that some ecosystem services are different in inland and coastal wetlands, the valuation methods are different in some cases. For example, the damage cost avoided method has been proposed for the ecosystem service of protection against storm and coastal flooding, (Mehvar et al., 2018) specifically used for coastal wetlands. However, due to the similarities in most types of ecosystem services provided by coastal and inland wetlands, many similar valuation methods are used for coastal and inland wetlands.

Step 2: Identifying spatiotemporal scales and how to determine beneficiaries and stakeholders related to each type of ecosystem service:

- **Define the boundaries (temporal and spatial scales)**

Natural asset conditions affect ecosystem functions, processes, and services at different scales. Therefore, considering an appropriate scale is critical for monitoring and analyzing ecological landscape patterns and ecosystem services. Many ecosystem services, such as recreation, primary production, and microclimate regulation, are site-specific. At

Table 2
Most important valuation methods proposed for different types of ecosystem services for coastal and inland wetland of Iran reproduced from [(Thapa et al., 2020; Baral et al., 2016; Wondie, 2018; Li et al., 2020; Zhou et al., 2020; Environmental Management Division, 2019; Gómez-Baggethun et al., 2019; Gunderson et al., 2016; Barbier, 2019; Qian and Linfei, 2012; Souza et al., 2014; Demirbugan, 2019; GEF International Waters: Learning Exchange and Resources Network (IW:LEARN) 2748; Briones-Hidrovo et al., 2020)].

The most important proposed valuation methods	Example	Type of ecosystem service
- Market price method - Production function approach - Replacement cost	Food production (agricultural products such as legumes, fruits, vegetables, mushrooms, fish, and aquaculture and livestock products)	Provisioning
- Market price method - Replacement cost - Production function approach	Freshwater supply for domestic (drinking water, washing) and irrigation uses	
- Market price method -Production function approach - Replacement cost	Raw materials (reed, fodder, timber, sand, and peat)	
- Market price method -Production function approach	Medicinal resources	
- Market price method -Production function approach	Genetic resources	
- Market price method -Production function approach	Ornamental resources (This service is specific to coastal wetland)	
- Damage cost avoided method - Replacement cost - Shadow project method - Defensive Expenditure - Production function approach	Erosion control, soil retention, and runoff/sediment balance and conservation	Regulating
- Damage cost avoided - Replacement cost -Shadow project method - Production function approach	Water flow regulation (flood control)	
- Damage cost avoided - Replacement cost - Production function - Defensive expenditure	Treatment and improvement of water quality (pollution control and removal of pollutants)/ waste treatment	
- Hedonic price method - Damage cost avoided	Climate regulation (global, regional, and local)(temperature retention/rainfall)	
- Replacement cost -Social carbon cost - Damage cost avoided -Production function approach -Market price	Gas Regulation (carbon sequestration and oxygen emission)	
- Production function approach	Groundwater recharge	
- Replacement cost - Production function approach - Damage cost avoided	Soil retention	
- Replacement/Substitute cost - Production function approach - Damage cost avoided - Hedonic price method - Shadow project method - Defensive Expenditure	Disturbance and natural hazards regulation (Coastal protection against storm by wave dissipation, water balance, and flood control) (This service is specific to coastal wetland)	
- Replacement cost - Production function approach - Market Prices	Biological control (Wetland as a habitat for the natural control of plants and animals acts the natural control of predators and parasites/ pest regulation).	
- Travel cost - Contingent valuation method - Hedonic price method - Choice Modeling -Production function approach -Market price	Recreation, ecotourism and commercial fishing, recreational fishing, and water sports (local recreational opportunities, etc.)	Cultural
- Contingent valuation method - Hedonic price method - Production function approach	Culture and art (architecture, historical values)	
- Contingent valuation method - Hedonic price method - Decision science approach[1] - Travel cost method	Spiritual values	
- Random utility/discrete choice[2] - Travel Cost - Market price method -Contingent valuation method - Production function approach	Scientific, research, and educational activities	
- Replacement cost - Contingent valuation method - Hedonic price method	esthetic value	
- Choice modeling - Contingent valuation method - Hedonic price method	Option, existence, and bequest values	

(*continued on next page*)

Table 2 (*continued*)

The most important proposed valuation methods	Example	Type of ecosystem service
- Replacement cost - Production function approach - Contingent valuation method - Hedonic price method - Market price - Damage cost avoided	Provision and preservation of habitat for plants and animals/ biodiversity protection	Life supporting and habitat
-Damage cost avoided - Contingent valuation method	Soil formation (storage of organic matter)	
- Replacement cost - Damage cost avoided - Production function approach	Nutrient cycle	
- Contingent valuation method - Production function approach	Conservation of genetic diversity (high capacity to support biodiversity by species with higher genetic diversity than other species, conservation of gene reservoirs)	
- Production function approach - Contingent valuation method	Preserving the life cycle of migratory species (including nursery service for commercially valuable fish species)	
- Production function approach	Primary production	

[1] Decision science approach: This method is used to estimate the value of cultural and spiritual services. The decision-making science approach uses an advisory process to produce information about individuals' values. This information helps individuals understand and evaluate the multiple properties of contradictions. The ultimate goal is for the individual or group to rate alternatives (e.g., various projects); then, realizing the differences in the dimensions and characteristics of the alternatives, one of them can be selected according to the scores. The score of an alternative is usually higher only in some dimensions (aspects), and not all, which means that contradictions arise inevitably when choosing between alternatives (Forest Europe growing life, 2021).

[2] Random utility/discrete choice: This method is used to estimate the value of recreational services. Discrete selection / random utility models are derived from this empirical assumption: Individuals know their priorities with certainty, but these priorities have components that the empirical observer does not have access to. Thus, individuals' priority parameters can be retrieved statistically up to reaching a random error component. This econometric approach is used to estimate modern models of travel costs (Forest Europe growing life, 2021). In general, this method shows among the options with different levels of ecosystem services and different costs, which option is preferred.

the same time, erosion control, flood control, and water supply are addressed on a landscape or watershed scale, and climate regulation associated with global carbon sequestration acts on a global scale. In general, the appropriate scale for analyzing ecosystem services can be defined by the spatial and temporal dimensions to which service delivery is most dependent (Zarandian, 2015). The goods and services offered by natural ecosystems are subject to the constraints of a natural factor called "*scale*," without which different economic and ecosystem assessments cannot be realistic. In terms of ecological or economic viewpoints, scales are raised concerning the spatial and temporal dimensions of the occurrence of natural phenomena. In other words, specific spatial and temporal conditions predispose the emergence of ecosystem services in terms of scale. Many economic processes related to revenue generation and market exchanges and their governing conditions show their effectiveness and efficiency depending on the necessary scales.

By presenting the net value of environmental benefits over specific periods, the temporal boundaries for the continuation of ecological processes in each ecosystem will also be analyzed. In this way, calculating the values of the current flows of ecosystem goods and services momentarily and for a short period of time will be avoided. The unsustainabilities due to the current withdrawals and the consequences on the decline of environmental resources in the coming years, accompanied by a reduction in the flow of economic benefits related to ecosystem services, will be considered. Predictable changes in the value of the resulting goods and services should be measured following the Conventional discount rates for longer time horizons (20 to 120 years). Therefore, momentary approaches can still have practical capabilities for those ecosystems that have been less degraded by human interventions due to the remoteness from the scope of development activities (DoE 2013).

■ How to screen key goods and services of wetland ecosystems with the participation of stakeholders

In the first step, it is necessary to determine the "current and probable future situation in the production or non-production of various ecosystem goods and services," "services of the most importance," and "services with the most probability of future decline."

■ Identifying and interacting with stakeholders and beneficiaries of wetlands

Wetland stakeholders and beneficiaries are different in terms of wetland type and functions/services/benefits. Stakeholders may reside both upstream and downstream of a wetland. For example, although only people living around a wetland can directly benefit from fishing, many people living farther downstream of the wetland may benefit from its flood control function. For example, those who benefit from the water purification value may live in a town that discharges sewage into the wetland. In contrast, the flood control function may benefit people living downstream. Some stakeholders do not live near wetlands. This is especially true when stakeholders consider wetlands' intrinsic/existence benefits (e.g., biodiversity and cultural heritage) to benefit the general public and more individuals. This demonstrates the importance of identifying the stakeholders who benefit from the functions/services of the wetland being valued (Kyophilavong, 2011).

Identifying stakeholders (e.g., local communities, NGOs, authorities, etc.) as an essential factor helps better understanding the site, key ecosystem services, and beneficiaries. After selecting the ecosystem services to be valued, it is required to identify stakeholders to understand better how to use them (Merriman and Murata, 2016). How to engage stakeholders is an important factor in ensuring the sustainability of wetland ecosystems. The broader the ecological scales, the wider the range of stakeholders with different capacities are expected to interact. How to identify and analyze such stakeholders is a topic that this study will address. Methods such as interviews with experts, scholars, and members of local communities will be used to identify the real stakeholders. The most important scales to be considered by stakeholders will be international, national, provincial, local, household, and individual scales.

Step 3: Quantify impacts influenced to ecosystem services and selection of appropriate valuation methods to estimate the economic value and cost of environmental damages for each of the ecosystem goods and services identified and quantified

For the economic valuation of any service, the most appropriate method should be identified and used. The types of ecosystem

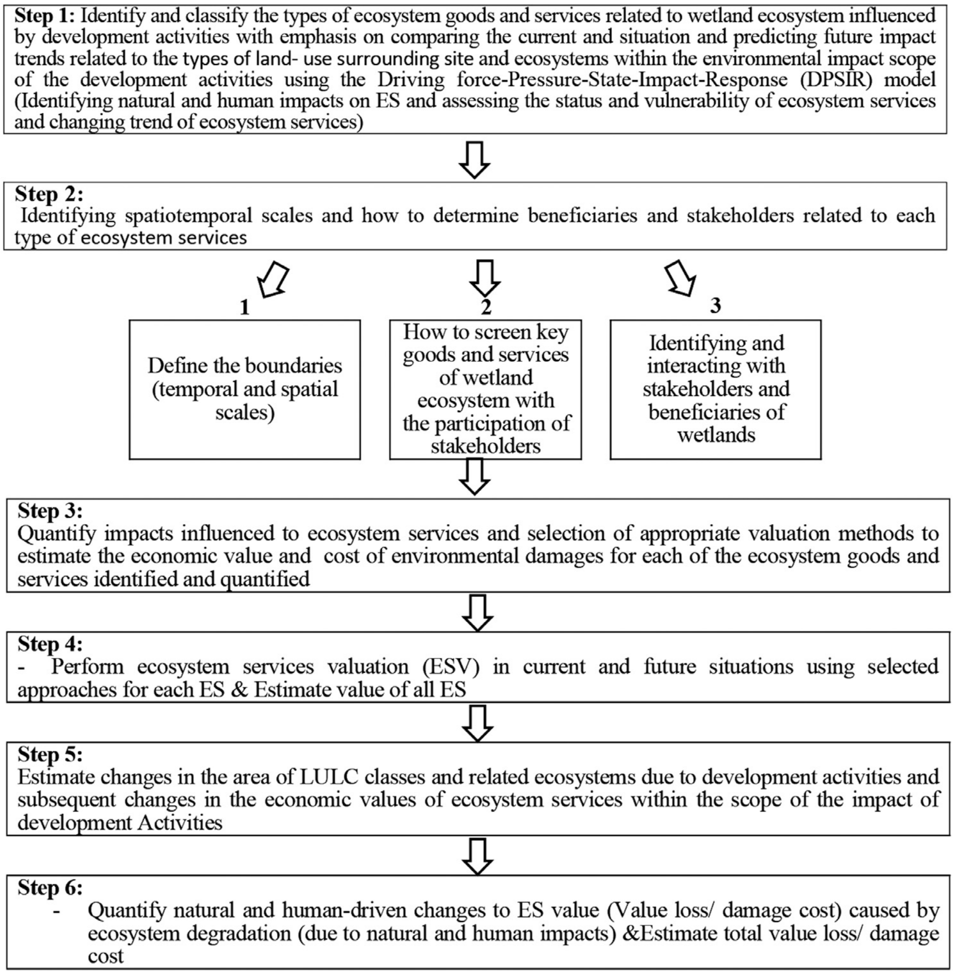

Fig. 1. Conceptual framework of research methodology.

services and the most important valuation methods are presented in Table 2.

Step 4. Perform ecosystem services valuation (ESV) in current and future situations using selected approaches for each ES & Estimate the value of all ES

If the benefit transfer approach is chosen; then, the value coefficients of Costanza et al. (2014) or De Groot et al. (2012) can estimate each land use/land cover type's ecosystem service values Eq. (1). The total value of ecosystem services for the years considered is calculated by multiplying the area of a certain land-use type in the adjusted coefficients of the value of ecosystem services, derived from the weight coefficients of ecosystem services per hectare of each biome.

$$ESV = \sum \left(A_k * VC_k\right) \tag{1}$$

where;

ESV= Estimated total value of the ecosystem service, Ak=area (ha), and VCk= Value coefficient for the desired ecosystem (US dollars/hectare/year), for example, for the land use type k. The percentage change in ESV_S in the studied years is calculated based on Eq. (2), as below.

$$Percantage\ ESV = \left(\frac{ESV_{t2} - ESV_{t1}}{ESV_{t1}}\right) \times 100 \tag{2}$$

Where; ESV t2 (US dollars/ha/year)= estimated value of ecosystem services in recent years, and ESV t1 (US dollars/ha/year)= estimated value of ecosystem services in the previous year. Positive values indicate an increase in ESVS, while negative values show a decrease in ESVS. The values of services provided by the unique functions of the ecosystem in the study area are estimated using Eq. (3), as follow:

$$ESV_f = \sum \left(A_k * VC_{fk}\right) \tag{3}$$

ESVf= Estimated ESV of the function f, Ak=area (ha), and VCfk = value coefficient (USD/ha/year) for the land use type k (Msofe et al., 2020). The economic value of ecosystems can be computed as follows:

$$EV = si * pi \tag{4}$$

Where; si is the amount of supply and pi is the "shadow price" for the ecosystem service. The total economic value is calculated as follows (Demirbugan, 2019):

$$TEV = \sum s_i p_i \tag{5}$$

Step 5: Estimate changes in the area of LULC classes and related ecosystems due to development activities and subsequent changes in the economic values of ecosystem services within the scope of the impact of development Activities

One common method for estimating damage to ecosystems is to monitor changes in ecosystem services over specific periods. By comparing the changes of ecosystems in different periods, the amount of damage can be estimated. For example, changes in ESV can be assessed by linking land-use change to ESV valuation (Xiao et al., 2018). The dynamicity index is used to calculate the rate of change in land cover, which is calculated as follows:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \tag{6}$$

where; K| is the dynamicity index, Ua and Ub are the LULC area at the beginning and end of the studied periods, and T is the number of years studied (Qian et al., 2018). The following formula can also evaluate the LULC spatial-temporal changes:

$$CP - LULC_k = \frac{LULC_{end} - LULC_{start}}{LULC_{start}} \times 100 \tag{7}$$

$CP - LULC_k$ Is the change in the area of the land use type k, LULCend, and LULCstart are respectively the area of the land use type k in the past and present years[4].

Step 6: Quantify natural and human-driven changes to ES value (Value loss/ damage cost) caused by ecosystem degradation (due to natural and human impacts) & Estimate total value loss/ damage cost

After the estimates, a dynamic assessment of the effect of ecosystem degradation on the supply of ecosystem services and the resulting economic damage will be required. Therefore, the following calculation should be performed based on the balance of ecosystem services to obtain a net value.

$$\text{ESA} = \Delta \text{ES}_n = \sum \text{ES}_a - \sum \text{ES}_b \tag{8}$$

In which; ΔESn is the net value of ecosystem services in dollars/year, and ES is the total value of all ecosystem services offered before (b) and after (a) of the development activity in dollars or IRR/year. This only applies when land-use change is directly involved in development activities (Briones-Hidrovo et al., 2020).

Choose the right discount rate

The maximum social discount rate used to evaluate environmental assets, environmental damage assessment of development projects, and economic evaluation of investment projects in Iran are 5% (Nazari, 2020).

■ **Economic Valuation and Estimation of Damages cost to Wetland Ecosystem Services (Loss of Value of ES) Due to Development Activities Using Benefit Transfer Method:**

The benefit transfer approach is a useful method for developing countries (Chaikumbung et al., 2016). The benefit transfer method will be appropriate when there is insufficient time to conduct economic valuation or environmental damage cost assessment studies. This method uses the average standardized values of ecosystem services in each biome (de Groot et al., 2020). The following points are worth noting while estimating ES costs:

To calculate the ES costs of each biome using the value/benefit transfer method, ESVs can be retrieved from databases ESVD, (de Groot et al., 2020), TEEB, (Van der Ploeg et al., 2010); Costanza et al. (2014), or De Groot et al. (2012). The results of related studies are very important when using the benefits transfer method. To estimate the economic value of ecosystem goods and services by the benefit transfer method, the estimated ESVs of databases TEEB (Van der Ploeg et al., 2010) and ESVD (de Groot et al., 2020) or De Groot et al. (2012) can be used for some values | in the study area (e.g., ESV of land uses around the site of development activities, such as coastal or inland wetlands, rangelands, and temperate and tropical forests). The values estimated by Costanza et al. (2014) or ESVD (de Groot et al., 2020) can be used for ecosystem services related to agricultural lands around the development sites. Using the economic values available in the database of TEEB (Van der Ploeg et al., 2010) or ESVD (de Groot et al., 2020) and according to the ecological conditions of Iran, a minimum value can be adjusted for the country over a period of one year. The relevant values should be updated using the data of older databases (e.g., de Groot et al., 2020). Dollar values can be updated from the reference site of areppim (Areppim information 2021). Finally, based on the area of the ecosystems affected by the development activity multiplied by the average "values of"/"costs of damage to" ecosystem services per biome, the total economic value loss (total cost of environmental damage) can be estimated.

We can study the section on economic indicators in the statistics related to the gross domestic product (GDP) published by the Central Bank of the Islamic Republic of Iran (CBI, 2021) and/or the summary report of the economic developments in this country on the website of this bank to take into account the share of the total economic value the relevant ecosystems of Iran's GDP and estimate the share of lost economic value in the study area of the country's GDP.

In the benefit transfer method, the original global ecosystem service valuation data extracted from the Ecosystem Services Value Database (de Groot et al., 2020) are adjusted in accordance with Eq. (9) by taking into account the difference in the income elasticity of the marginal willingness to pay for Iran. The adjusted values of wetland ecosystem services in Iran are based on a dollar to Iranian Rial exchange rate (the NIMA currency (Persian acronym for "Integrated System of Foreign Exchange Transactions"), 230,000 IRR to USD) (IPRC 2021).

$$WTP_{PS} = WTP_{SS}\left(GDP_{PS}/GDP_{SS}\right)^{\varepsilon} \tag{9}$$

ε= Income elasticity of marginal willingness to pay, WTP_{PS}= Willingness to pay at the policy site (destination, the country where the value is used), WTP_{SS}= Willingness to pay at the site under study (origin, the country where the values transferred are originally calculated and transferred), GDP_{PS} and GDP_{SS}: GDP per capita in PPP (Purchasing Power Parity) dollars respectively at the policy site and the site under study (origin) (Figueroa and Pasten, 2012).

It is to be mentioned that Iran's per capita GDP to the world average and income elasticity of willingness to pay is estimated from the economic indicators GDP per capita, PPP (current international $) available at the World Bank website (The World Bank/Data, 2021).

The mean coefficients of standardized values of ecosystem services per hectare of coastal and inland wetlands and other relevant biomes (de Groot et al., 2020) were updated based on the price levels in 2021 using the reference site of areppim (Areppim information 2021). Then the corresponding values were adjusted (Figueroa and Pasten, 2012) for Iran according to Eq. (9) (Tables 3,4).

It should be noted that taking into account the definition of the spatial scale of the study area, the various types of land use around the wetland site and/or the ecosystems in the area influenced by the environmental effects resulting from development activities such as forests, woodlands, rangelands, and farmlands can also be considered in the calculations related to the values and damage costs of ecosystem services in estimating the value and/or cost of the damages to ecosystem services in Iranian wetlands. Table 3 shows the mean of the standardized values of the ecosystem services per hectare of the mentioned ecosystems that have been adjusted for Iran.

The mean of the adjusted ecosystem service value coefficients of the Iranian coastal (mangrove) and inland wetlands per hectare based on price levels in 2021 are listed in Table 4 (in IRR and USD). As shown in table 4, the sum of the "means" of the adjusted ecosystem service values per hectare for the Iranian coastal mangrove and inland wetland ecosystems are estimated to be 67,665 USD and 42,171 USD (15,565 and 9698 million IRR), respectively. The sum of the mean of the estimated values related to the provisioning, regulating, and life support services per hectare for the coastal wetlands is estimated to be higher than that of the inland wetlands. In contrast, the estimated mean value of the cultural services for the inland wetlands is higher than that of the coastal wetlands.

As shown in Table 4, water supply and food production services are of the highest value for coastal wetlands and inland wetlands, respectively, among the provisioning services.

Furthermore, the disturbance regulation service is the most valuable regulating service for coastal and inland wetlands. The genetic diver-

Table 3
Mean adjusted values of ecosystem services for wetlands, forests, woodland, grassland, and cultivated areas of Iran (USD/hectare/year: 2021 price level).

Cultivated areas	Grassland	Woodland	Temperate forests	Tropical forests	Inland wetlands	Coastal wetlands(mangroves)		Ecosystem services
442	0	7	3	522	5227	5823	Food	Provisioning Services
523	271	0	0	41,498	1676	9099	Water supply	
5	552	1	29	10,176	1458	3861	Raw materials	
0	0	0	0	14	52	0	Genetic sources	
0	0	1	0	3	0	0	medicinal resources	
0	0	0	0	0	0	0	Ornamental sources	
9	7	6	1381	268	30	1147	Air quality regulation	Regulating Services
9	63	78	417	570	130	1472	Climate regulation	
861	0	0	5	94	11,547	14,703	Disturbance regulation	
14	37	61	59	384	3153	1981	Regulation of water flows	
35	0	0	0	10	1771	3536	Waste treatment	
150	0	0	5	523	0	3466	Erosion control	
30	0	0	101	37	0	4834	Maintain the fertility of the soil	
1299	0	0	0	760	0	0	Pollination	
539	0	0	0	12	0	0	Biological control	
0	0	0	0	16	1635	1437	Life cycles maintenance of Species migratory	Life Supporting Services
0	0	0	0	6	2971	5760	Conservation of Genetic diversity	
343	0	33	31	0	43	290	esthetic information	Cultural Services
2688	80	107	244	45,763	2306	3785	Recreation and tourism opportunities	
14	246	186	170	4	99	3372	Culture, art, and design	
0	0	0	0	0	1	0	Spiritual experiences	
0	128	186	128	0	104	1239	Information for cognitive development	
0	0	2	2094	2566	9967	1861	Bequest and existence values	
6960	**1385**	**667**	**4666**	**103,224**	**42,171**	**67,665**	The l value of ecosystem services per hectare in USD	

Sources: Mean adjusted (Wondie, 2018) of ecosystem services values are extracted from Ecosystem Services Valuation Database (ESVD) (Kyophilavong, 2011) and updated (The World Bank/Data, 2021) for 2021 (de Groot et al., 2020; Areppim information 2021; Figueroa and Pasten, 2012).

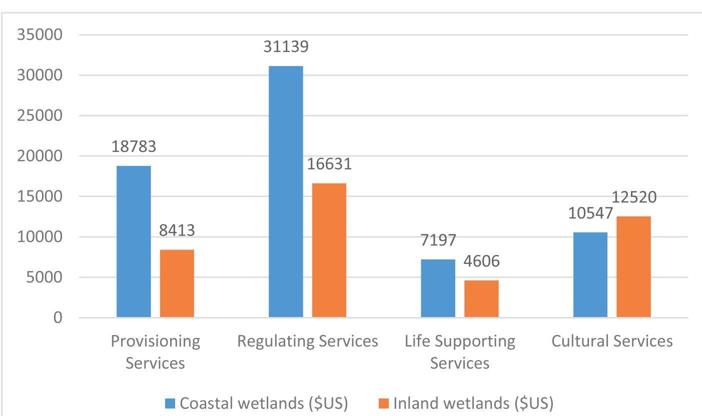

Fig. 2. Comparison of the mean values of the various ecosystem services separately for Iranian inland and coastal wetlands (USD/hectare/price levels in 2021).

sity preservation service is of the highest value for coastal and inland wetlands among the life support services.

Among the types of cultural services, recreational and tourism opportunities service has the highest value for coastal wetlands, while those related to existence and bequest values are of the highest value for inland wetlands.

Fig. 2 manifests a comparison graph related to the values of various ecosystem services in the coastal and inland wetlands. The estimated total value of the coastal wetlands' provisioning, regulating, and life-support services are higher than that of the inland wetlands. However, the estimated total value of the cultural services of the inland wetlands is more than that of the coastal wetlands. In general, the coastal and inland wetlands contribute 62% and 38%, respectively, to all ecosystem services' total value (Fig. 3).

4. Discussion

Valuation of wetland services is an important issue for developing countries, among them Iran, where the livelihood of local communities is dependent on wetlands and using the goods and services they provide.

Table 4
Mean adjusted values of ecosystem services for coastal and inland wetlands of Iran (USD & Million IRR /hectare/year: 2021 price).

Inland wetlands (Million IRR)	**Coastal wetlands (Million IRR)**	**Inland wetlands ($US)**	**Coastal wet-lands**(mangroves)**($US)**		**Ecosystem Services types**
1202	1339	5227	5823	Food	Provisioning Services
386	2093	1676	9099	Water supply	
335	888	1458	3861	Raw materials	
12	0	52	0	Genetic sources	
0	0	0	0	medicinal resources	
0	0	0	0	Ornamental sources	
		8413	18,783	**Sum**	
1935	4320				
7	264	30	1147	Air quality regulation	Regulating Services
30	339	130	1472	Climate regulation	
2656	3382	11,547	14,703	Disturbance regulation	
725	456	3153	1981	Regulation of water flows	
407	813	1771	3536	Waste treatment	
0	797	0	3466	Erosion Control	
0	1112	0	4834	Maintain the fertility of the soil	
0	0	0	0	Pollination	
0	0	0	0	Biological control	
				Sum	
3825	7163	16,631	31,139		
376	330	1635	1437	Life cycles maintenance of Species migratory	Life Supporting Services
683	1325	2971	5760	Conservation of Genetic diversity	
1059	1655	4606	7197	**Sum**	
10	67	43	290	esthetic information	Cultural Services
530	871	2306	3785	Recreation and tourism opportunities	
23	776	99	3372	Culture, art, and design	
0/2	0	1	0	Spiritual experiences	
24	285	104	1239	Information for cognitive development	
2292	428	9967	1861	Bequest and existence values	
				Sum	
2879	2427	12,520	10,547		
9698	**15,565**	**42,171**	**67,665**	The value of ecosystem services per hectare in USD / Million IRR	

Sources: Mean adjusted of ecosystem services values are derived from Ecosystem Services Valuation Database (ESVD) and updated for 2021 (de Groot et al., 2020; Areppim information 2021; Figueroa and Pasten, 2012).

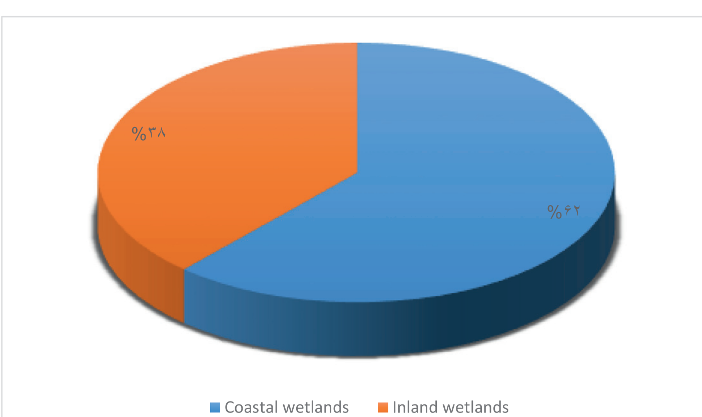

Fig. 3. Comparison of the mean shares of the ecosystem services separately for Iranian coastal and inland wetlands.

This is because it helps communities to appreciate the importance of ecosystem service values and encourages them to protect these services through sustainable use. Iran has a variety of wetlands that cover important areas of the country and, through ecosystem functions, provide a diverse range of benefits for the country's population and at a wider level in the region. Due to insufficient awareness of policy-makers, planners, and other stakeholders about the value of the benefits provided by wetlands, many of these vital and valuable resources are at risk of degradation and conversion to other land uses. The results of this study will be an important tool for policy-makers and stakeholders during the development of management programs for wetland sustainability. The extent of degradation and lost value of ecosystem services can be quantified and compared with each other. Therefore, it is possible to determine the maximum and minimum damage to various ecosystem services due to development activities. For the economic evaluation of wetlands, an ecosystem services approach is suggested. One of the most commonly used methods for estimating the extent of damage to ecosystems is monitoring changes in ecosystem services in specific periods. It will thus become possible to estimate the damages by comparing the changes that have occurred in each ecosystem in the different periods. When changes occur due to the implementation of development projects, monitoring these changes before and after implementing the project is necessary. In some cases, the possible damage is only estimated before the project is implemented. This is often done to include the "damage to the ecosystem services" in the process of cost-benefit analysis and to make the optimal decision regarding the implementation, non-implementation, or selection of the alternative option.

Conclusion

Valuation helps local communities design compensatory tasks such as payment for ecosystem services and sustainable utilization of wetland resources. On the other hand, in developing countries, economic valuation facilitates the transition to ecosystem-based management for the high priority of management measures (Torres and Hanley, 2016). It is suggested that the ecosystem services approach be used for the economic valuation of wetlands, and the values must be estimated for a reasonable period (5 to10 year period). Since the livelihoods of the local communities depend on the wetland, it is necessary to take stakeholders and beneficiaries of the wetland into consideration in studies on the valuation of wetlands. The spatial and temporal boundaries of wetland ecosystems should be defined properly. Using and localizing the existing economic values of the wetlands using ESVD (Ecosystem Services Valuation Database) and considering the ecological conditions of Iran, we can use this database to adjust the minimum value for the annual period in this country. Finally, the extent of degradation and lost values of all the ecosystem services can be quantitatively estimated in the Iranian Rial (IRR) and compared. Consequently, it becomes possible to determine the most and least extensive damage to various ecosystem services by development activities. This study shows that the sum of the "means" of the adjusted ecosystem service values per hectare for the Iranian coastal mangrove and inland wetland ecosystems is estimated to be 67,665 USD and 42,171 USD (15,565 and 9698 million IRR), respectively. Economic valuation helps to identify the financial mechanism through the various ES provided by the site. Financial mechanisms may include creating schemes, such as payment for ecosystem services, whereby a stakeholder or beneficiary helps in the management of a wetland ecosystem in order to ensure that the benefits will be perpetuated in the future (RRC-EA 2020). According to the high importance of ecosystem goods and services of wetlands, sustainable financial resources for wetlands need to be expanded and developed (Baral et al., 2016). It is recommended to use the economic tools approach and apply corrective taxes to compensate for the environmental damages caused by development activities.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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