RESEARCH ARTICLE

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Determination of Minimum Ecological Value of Wetland and Assessment of Hydrologic Alteration Indicators Affecting Local Communities' Livelihood: Case Study Anzali Wetland

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Abstract: Wetlands are of great importance to human society due to their direct and indirect delivery of goods and services; therefore, there has been a growing interest in the restoration and preservation of wetlands in different communities. To preserve the ecological values of wetlands and, thus, to ensure the local communities' livelihood, it is essential to supply the water demand to provide ecological services relevant to the organisms in the ecosystems and also to the local communities around the wetland. A conceptual model derived from the integrated water resources management principles was used to assess the economic damages caused by the degradation of ecological conditions in Anzali Wetland. In order to quantify the assessment of this study, initially, the economic value of the entire wetland was estimated at 592,960 billion Iranian rials, which includes direct use value, indirect use value, and non-use value of about 28.5%, 10.5%, and 61%, respectively. Then, by defining the optimal and minimum acceptable conditions of Anzali Wetland in terms of ecological health, the economic value of wetland functions and services within the goals set for the livelihoods of local communities was obtained in the corresponding ecohydrological conditions. Finally, the value of wetland services was evaluated by comparing the current reduced economic value with both minimum and optimal ecological conditions. In this paper, by introducing the indicators for the vital wetland-related occupations, it was shown how disturbing the hydrological balance by impairing the tangible ecological services of Anzali Wetland influenced the IWRM, particularly the livelihoods of local communities in this system.

Keywords: ecosystem service, livelihoods, local communities, valuation methods, IWRM

1. Introduction

A sustainable development approach in wetlands concerning different consumption goals in urban development, tourism, and population growth has always been challenging from a different point of view (Javadi et al., 2022; Jafari et al., 2021a, 2021b). The lack of understanding or underestimating the economic benefits of natural resources is one of the essential reasons for not paying attention to wetlands. In the studies presented so far, the socioeconomic issues of wetland residents have been less considered in calculating the water requirements of wetland ecosystems. In contrast, today, due to the dependence of human societies on the ecological services of wetlands, it is necessary to consider socioeconomic concerns in addition to hydrological and ecological issues (Conservation of Iranian Wetlands Project, 2013). Today, most of the focus in the studies of aquatic ecosystems is on the roots of the formation and ecological relationships of wetlands, improving knowledge about biodiversity and their ecological processes, and the connection of wetlands with local communities around them in the form of the concept while ecosystem services have received less attention. Although wetlands contribute to improving the well-being and living conditions of humans through the provision of ecosystem services, the recognition of these benefits and advantages is often neglected in the decision-making and management processes. Water is known as an essential factor in the formation of these services. Due to the

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limited water resources and the increasing economic value of water as a main infrastructure for the development of all sectors, the ecological needs of nature have been neglected for a long time. In general, practically, the water that has been available to nature for many years and caused the evolution and development of ecosystems has been gradually allocated to human use. During the last few decades, due to this process, some natural ecosystems have been seriously damaged (Shokoohi & Amini, 2014). At the basin management level, decision-makers have concluded that to address this challenge, the partial look at the water and its consumers should be prevented as far as possible, and the integrated and interdisciplinary management of the basin be considered (Meng et al., 2019). Disregarding the integrated water resources management (IWRM) at the basin level causes the destruction of wetlands and associated ecosystem services, which has many adverse effects on the livelihoods of local communities. Burkhard et al. (2009) and De Groot et al. (2012) evaluated the wetland ecosystem services and functions using the economic valuation method of wetland ecosystem services and a combined method based on market and value transfer. Among the types of services and functions of the wetland, the focus of the current research is on the services that are directly related to the livelihood of human communities dependent on the wetland. In a study, Ramachandra et al. (2011) classified the total economic value of Varthur Wetland as components of direct use and indirect use values and option values, and existence values, known as non-use values. They assessed this sewage-fed wetland value, analyzed the water quality, and surveyed the socioeconomic component by contingency valuation technique. van Dam et al. (2013) studied the ecohydrology function and livelihood outcomes in the Nyando papyrus wetland in a 34-node Bayesian network model for dry and wet seasons in an average year. They showed that flooded condition has the most positive effects on the ecosystem function and the most damaging effects on livelihood outcomes compared to agriculture and harvesting. Kundu & Chakraborty (2017) researched the economics of aquaculture, horticulture, and agriculture under the waste recycling practices concerning hydrology. Also, Dar et al. (2020) investigated the significant wetland threats, such as pollution, siltation, encroachments, urbanization, and floating gardens which exasperate the ecologic condition. Feng et al. (2021) assessed services of the habitat quality, carbon storage, water yield, and soil retention services of the Beijing–Tianjin–Hebei region and tracked their trade-offs. Later, Liu et al. (2022) explored spatial mismatch in ecosystem services in the Pearl River Delta. They mapped the ecosystem service flow path of the cities and concluded the food demand exceedance of the food supply. Sati (2023) investigated livelihood sustainability in terms of ecosystem services valuation in the Himalayan region. They recommended that the ecosystem services valuation should be analyzed on a suitable methodology basis, and green bonus and share of ecosystem services should be given to the native people of the upstream regions. The main purpose of this research aims to show, providing special conditions in the wetlands (e.g., favorable or minimal conditions) by neglecting the wetlands' rights and without considering related functions and services, how much can affect sustainable development from the perspective of threatening marginal economic interests in the wetlands area. The proposed method in this study is a conceptual model derived from the principles of integrated management of water resources. In this method, at first, the economic value of the wetland is estimated at the current conditions, and then by determining the ecological conditions of the wetland, it is evaluated in two scenarios, minimum and optimal conditions. In the end, by introducing indicators for the main activities related to the wetland, the damage caused to the wetland is evaluated and the value of tangible services of the wetland is estimated on the living conditions of the local communities.

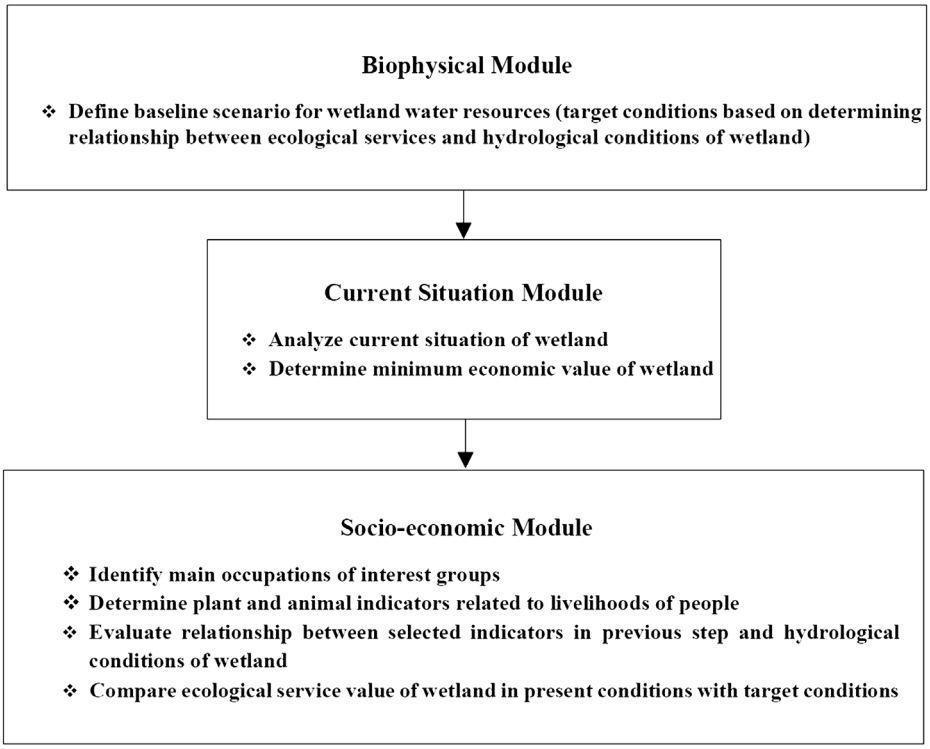
2. Materials and methods

A conceptual model based on IWRM studies was used to conduct the research. For this purpose, three steps were considered for the studies. In the first step, the target conditions in the Anzali Wetland were defined as baseline scenarios at two minimum and optimal levels in the wetland. According to the definition of optimal hydrological conditions for ecological services conservation, the water demand level should be enough so that a species can survive in the best possible conditions and no population decline happens to the wetland for species or their nesting. The minimum hydrological condition definition is when the volume, area, or depth of water becomes too low that the prominent species would become extinct or immigrant birds not return to the wetland. In this case, the water input is significantly reduced compared to the natural conditions, but wetland conditions remain ecologically acceptable. In the next step, some wetland ecological services were identified, especially the ones playing an essential role in the local people's livelihood. Later, their economic value was calculated. Wetland services are generally divided into two categories of use and non-use (existence) services, and utility services are divided into direct and indirect ones. Bird, fishing, and hunting were identified as direct utility services in the Anzali Wetland. The market pricing method was used for the economic valuation of direct utility services, and the contingent valuation method was selected for tourism. Also, for the economic evaluation of all non-use wetland values, including those mentioned and the existence value. The option value and bequest value of the contingent valuation method were selected. Therefore, the main local people's occupations were identified at first. Later, the hydrologic alteration index under optimal and minimum conditions was assessed considering the present condition. It was shown which part of the wetland's ecological values and services was affected and which groups of local people either quit their jobs or had less income than before. Consequently, the direct and market valuation methods based on tangible factors were used to compare the economic value of wetland ecological services in the present and target conditions. To sum up, this study assesses the impact of physical changes on the wetland regarding the benefits of human societies depend on it. It estimates the possible changes and differences arising from the value of market products and services related to wetland ecological services, such as fishing or bird hunting. Figure 1 illustrates the steps in this research in the form of a conceptual model developed to determine the economic value of tangible and vulnerable wetland ecological services within the IWRM framework.

2.1. Study area

The Anzali Wetland is one of the most important components of the Caspian ecosystem and is located southeast (37° 25' N, 49° 28' E) of the Caspian Sea. This wetland with an area of about 15,000 hectares is 1 of the 24 international wetlands of Iran, which was introduced to the Ramsar convention office in 1971 along with 18 other wetlands (Ashoori & Abdoos, 2013; Sheet, 2012). The wetland has a catchment area of 3610 square kilometers which has an annual average flow of about 2400 million cubic meters. This area includes 9 main rivers and despite the connection of the wetland with the Caspian Sea in downstream, its water is fresh (JICA, 2005). Anzali Wetland is the habitat of

Figure 1
Flowchart of steps in the conceptual model for determining the economic value of wetland ecological services within the IWRM framework

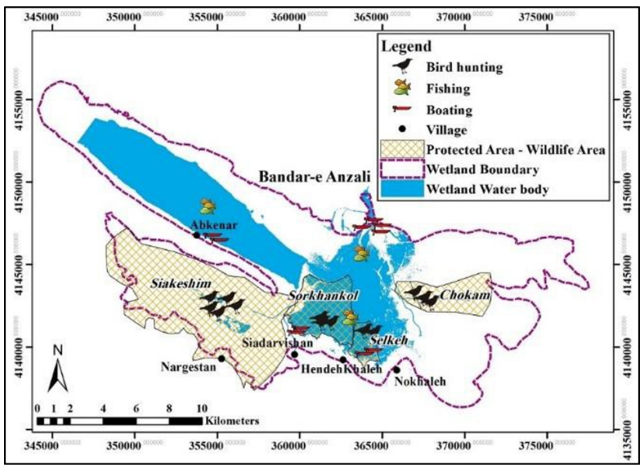


many species of endangered birds and fish with high economic values (Ashoori & Varasteh, 2014; Esmaeili et al., 2014). This ecosystem has a high potential for attracting tourists and also provides many services and functions for its residents. Figure 2 shows the geographical location and different parts of the Anzali Wetland.

2.2. Data

In this method, the price of an environmental product is available on the market or can be directly determined by asking in the market. The required data in this study to evaluate the economic value of Anzali Wetland, such as the amount of fish catch, information about fishing cooperatives, and bird census statistics, were obtained from the General Directorate of Fisheries of Guilan Province and the Guilan General Directorate of Environmental Protection. Also, the bank interest rate was based on the statistics of the Central Bank of Iran, and the base price of the desired fish and birds was also considered based on the market price. All the data used in this study are presented in Table 1.

Figure 2
Location and attractions of different parts of the Anzali Wetland



2.3. Contingent valuation method

Contingent valuation is the most well-known method in the group of demand-based approaches that relies on consumer decisions and behavior. This method is used to measure people's willingness to pay (WTP) for environmental goods and services. In other words, this method attempts to determine the WTP of people under hypothetical market scenarios (Lee & Han, 2002). The ultimate goal of this approach is to obtain an accurate estimate of the interests that come from changing the production levels or prices of some public and non-market goods and services. There are three methods to calculate the WTP. The first method is an average WTP, which is used to calculate the expected value of WTP by numerical integration of the regression equation of the price function in the range of 0 to $+\infty$, The second method is an average total WTP, which is used to calculate the expected value of WTP by numerical integration of the price function in the range of $-\infty$ to $+\infty$. The third method is called the partial mean WTP (in a given range of the price function) and is used to calculate the expected value of WTP by numerical integration in the range of zero to the maximum

Table 1
Level, area, and volume values in different ecological conditions of the wetland

Data	Description
The amount of fish caught Number of fishing cooperatives and number of fishermen	The statistics data (1996–2016)
Bird census statistics in wetland	The statistics data (1996–2016) (3 species of Eurasian teal, coots, and green duck as hunting index species)
The basic price of fish and birds	The statistics data (2016)
Bank interest rate	The statistics data (2010–2016) (to adjust future values to present value equivalents)

bid (A). Among these methods, the third one is the best, because it maintains the consistency of limitations with the theory and has a reasonable statistical efficiency (Lee & Han, 2002). The dependent variable for non-use values is the acceptance of the bid price for the wetland. This variable is obtained in response to the question, "Is the visitor willing to pay for using the site?". The customer would be willing to pay for an environmental good when their utilities are greater when they use the desired good and pays for it comparing when they do not (Park & Loomis, 1996). In mathematical terms:

$$\mathrm{U}(1, \mathrm{Y} - \mathrm{A}; \mathrm{S}) + \varepsilon_1 U(0, Y; S) + \varepsilon_0 \quad (1)$$

In Equation (1), U is a function of the indirect utility that an individual obtains. Y and A are the individual revenue and bid price, respectively, and S is the other socioeconomic characteristics attributes. ε0 and ε1 are random variables with a mean of zero and are distributed equally and independently. The utility difference (ΔU) can be described as Equation (2), in which U (0) refers to a situation where the individual does not pay for the wetland use and U (1) is related to the reverse situation (Park & Loomis, 1996). Consequently, the utility difference (ΔU) is defined as:

$$\Delta U = U(1, Y - A; S) - U(0, Y; S) + (\varepsilon_1 - \varepsilon_0) \quad (2)$$

If ΔU is greater than zero, this means that the respondent will maximize their utility by agreeing to pay a fee for using the site. In other words, the individual acceptance for payment is a function of Y, A, and S. Therefore, both dependent variables are qualitative for the valuation and only take the values of one and zero. In such cases, the regression models with qualitative variables are suitable models. In this study, the Logistic regression model (or Logit regression model) was used to investigate the effect of different explanatory variables on the individual WTP (Park & Loomis, 1996), Equation (3)

$$F(Z_i) = F_\eta(dU) = \frac{1}{1 + \exp^{(-dU)}} = \frac{1}{1 + \exp^{\{(-(\alpha + \beta A + \gamma Y + \theta S)\}}} \quad (3)$$

where is the cumulative distribution function and γ and θ are the estimated coefficients. Logit regression model parameters are estimated using maximum likelihood method. Therefore, the expected value of WTP is obtained by numerical integration in the range from zero to the highest offer (A) based on Equation (4).

$$E(WTP) = \int_0^{Max.A} F_\eta(dU)dA = \int_0^{Max.A} \left(\frac{1}{1 + \exp\{-(\alpha^* + \beta A\}} dA$$
$$\alpha^* = \alpha + \gamma Y + \theta S \quad (4)$$

where E(WTP) is the expected value of WTP and * is the adjusted width from the origin and added with the socioeconomic term to the width from the original origin (α).

3. Results

3.1. Determine the area and volume of the wetland by a comprehensive method in the current situation, optimal, and minimum conditions

In a study carried out by Modaberi and Shokoohi (2019) on the Anzali Wetland, the values of different levels of hydrological indicators such as water level, area, and volume of the wetland were obtained under optimal and minimum ecological conditions corresponding to those in the present study (Modaberi & Shokoohi, 2019). They performed a comprehensive study of the physicochemical situation, including morphology, water resources, and the biological and ecological situation of the wetland species. They concluded that the Whiskered Tern water bird was the primary indicator of the wetland's optimum and minimum ecological conditions. Whiskered Tern performs the nesting and breeding on the water chestnut plant mainly in summer when the water in the upstream watershed is extracted chiefly, and the evaporation rate from the water body is increased. They decided that supplying the volume of water needed for this species would meet the water requirement for others all year. The results of the study of these researchers, besides the current wetland condition, are shown in Table 1. It is assumed that providing suitable ecological conditions to determine the environmental flow for the Anzali Wetland benefits not only hydrological factors affecting the ecosystem but also socioeconomic functions. Moreover, in addition to the continuation of the ecosystem food chains, choosing appropriate water depth can affect various economic sectors, such as bird hunting and fishing, that can end promoting public welfare for fishermen and hunters. The present study uses two conditions obtained for the wetland ecological health at two optimal and minimum levels in the Modaberi and Shokoohi, (2019) study. The wetland characteristics for the 2016's condition were measured using the water level, and the area-volume-elevation curves of the Anzali Wetland were obtained (Modaberi & Shokoohi, 2019). According to the Table 2, the water level is currently −26.8, which has reduced the wetland volume to 82 million cubic meters.

3.2. Economic valuation of most effective ecological services of wetland

It is true that the Anzali Wetland, widely regarded as a precious natural resource, currently faces the severe risk of drying and falling into disuse. One of the main reasons for wetland negligence can be the need for more understanding of the economic benefits of this natural resource. The economic value of some wetland ecosystem services that contribute to the livelihood of local communities

should be studied to consider the principles governing water resource systems in the framework of IWRM. What will be discussed in this section is the determination of the total economic value of the use and non-utility services of the Anzali Wetland under the existing conditions (based on the data available in 2016).

3.2.1. Value of direct utility services

The market pricing method was used to calculate the value of direct utility services of the Anzali Wetland given the price of the services and the amount of the utility services. According to the available data, some of the direct utility services of the Anzali Wetland including fishing and bird hunting were calculated. The economic value of the Anzali Wetland fish was obtained according to the stakeholders, namely the wetland fishermen, from the product of caught fish by the base price. Table 3 shows the total value of fish caught on the Anzali Wetland in 2016.

The economic value of birds of prey on the wetland was also obtained by multiplying the number and price of birds. Table 4 shows the economic value of birds of prey on the wetland.

Table 2
Level, area, and volume values in different ecological conditions of the wetland

Wetland properties	Mean values of different hydrological indicators in wetland ecological conditions		
	Minimum (2009)	Optimal (1996)	Present (2016)
Water level (m)	−26	−25.7	−26.8
Area (km^2)	−102	122	61
Volume (MCM)	182	237	82

Table 3
The monetary value of fishing on the Anzali Wetland

Fish	Catching amount (103 kg)	Base price of fish (IRR/kg)	Economic value (million IRR)
Carp	500	14,700	7350
Common car	6.5	13,000	175.5
Caspian white fish	13.5	25,300	341.55
Other migratory fish	88.5	25,000	2212.5
Pike	200	23,200	4640
Other fish	3.5	15,000	52.5
Total	812	–	14,772.05

Table 4
Monetary value of birds of prey on Anzali Wetland

Bird types	Birds number	Bird value (IRR)	Total value (IRR)
Coot	16,829	30,000	504.87
Teal	28,326	35,000	991.41
Mallard	7985	80,000	638.8
Total	53,140	–	548,210

3.2.2. Value of indirect utility services

The indirect utility services are the services of an ecosystem that indirectly contribute to human well-being. One of the essential indirect use values is the recreational value of tourism areas. In this study, the contingent valuation method and the results of Mahmoodi et al. (2010) were used to evaluate the recreational value of the Anzali Wetland (Mahmoodi et al., 2010). The result of this study was adjusted using the discount rate compared to 2016 (Table 5). In this study, the mean WTP for the recreational use of Anzali Wetland was estimated to be 14,900 IRR, and with the adjustment compared to 2016, the WTP for the recreational use of the Anzali Wetland was finally estimated at 43,137 IRR. Table 6 shows the recreational monetary value of the Anzali Wetland.

3.2.3. Value of non-utility services

Another part of the economic value of the Anzali Wetland is the non-utility value of the wetland. According to Zebardast et al. (2010), the value for an indefinite time period is equal to 88039.2 IRR per year to estimate the maximum WTP of respondents. Since the bid price for the indefinite period was based on the assumption that it is paid at the present time (and, as a result, the respondents did not discount the future value in their minds), this value was corrected for 2016 based on the annual discount rate according to Table 4 (based on the annual interest rate of Central Bank of Iran). Finally, the non-use value of the wetland was derived from the annual number of visitors multiplied by the mean WTP. The results are presented in Table 7.

Table 5
Annual interest rate of Central Bank of Iran to adjust future values (Source: Central Bank of Iran)

Year	Interest rate (%)
2010	13
2011	13
2012	14.5
2013	14.5
2014	21.5
2015	20.5
2016	18
Mean	16.4

Table 6
Recreational value of Anzali Wetland

Economic parameter	Value (2016)
Mean willingness to pay (WTP) in IRR	4313.7
Number of visitors by person [16]	1,450,000
Recreational value of wetland in million IRR	6254.9

Table 7
Non-use values of Anzali Wetland in different years

Economic parameter	Value (2016)
Mean willingness to pay (WTP) in IRR	24,897.2
Number of visitors by person [16]	1,450,000
Recreational value of wetland in million IRR	36,100

Table 8
Minimum economic value of the Anzali Wetland

Services	Economic value (Million IRR)
Direct use (including ecological services such as hunting, and fishing)	16,907.13
Indirect use (recreational value)	6254.9
Non-use	36,100
Total	59,262.03

3.2.4. Minimum economic value of the Anzali Wetland

The minimum economic value of the Anzali Wetland equals the sum of direct use value, indirect use value, and non-use value. Table 8 shows the values for the minimum economic value of the wetland (in 2016).

3.3. Evaluation of the local people's livelihood by comparing ecological service values of wetlands in present conditions to target conditions

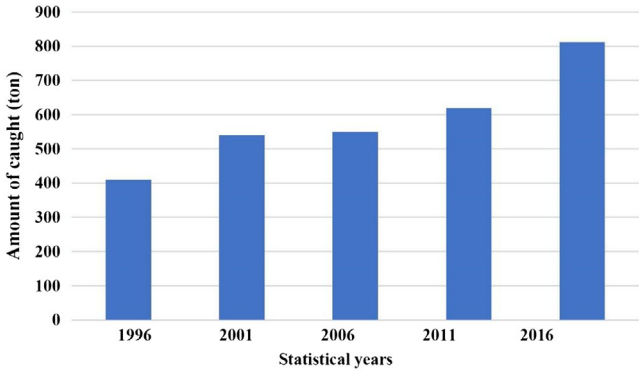
As mentioned in the preceding sections, the primary purpose of this study is to demonstrate the overall value of the wetland, to show the economic consequences of removing the services within the IWRM framework, and to address the socioeconomic aspects of the problem aiming to achieve sustainable development. Since the degradation and elimination of all wetland benefits are not conceivable, for now, and the primary purpose of this research is to illustrate the importance of preserving wetland water right to maintain its ecological health and ensuring economic justice for achieving sustainable development, the service degradation was confined to wetland fishing and bird hunting. The indicators were defined for each of the occupations to help determine the impact of wetland ecosystem conditions on the local communities. In this regard, the direct and market valuation methods were used for the economic valuation of wetland ecological services and for making a comparison in the present and target conditions.

3.3.1. Wetland fishermen's livelihood in the present situation comparing optimal conditions

Since there are no recorded statistics of illegal fishing in the Anzali Wetland, the data obtained from the fishing sector of the Guilan bureau of fisheries are considered. Consequently, the relationship between the wetland hydrological conditions and the local fishermen's livelihood was first investigated. The fishing amounts in different years, the percentage of fishing in each organization relative to the total fish caught on the wetland, and changes in the financial stock value of various organizations were selected as the final indicators of this sector. Figure 3 shows the fishing statistics in different years on the Anzali Wetland.

Accordingly, the highest and lowest fishing values belong to 1996 and 2016, respectively, and the increasing trend of fish catching has the reverse relation to the negative trend observed in the ecohydrological conditions of the wetland (Table 9). So, external factors might have been the cause. Changing the hydrological conditions of the wetland has little effect on the annual wetland fishing because the primary source of caught fish on the Anzali Wetland is the Caspian Sea, and the Anzali Fisheries Bureau breeds the fish fry on the wetland each year. So, it can be found that the selected indicator, namely the annual fishing amount, is not an appropriate indicator for the relationship between the wetland hydrological conditions and the benefits of native fishermen.

Figure 3
Fish catching statistics in different years (Guilan Bureau of Fisheries, 2018)



Other indicators examined were the percentage of fish caught in each organization relative to the total fish caught on the whole wetland and the stock value of fishing organizations. Table 8 shows the number of fishermen, the number of fish caught per year, the fishing percentage of each organization relative to the total fish caught on the wetland, and the stock value of each organization in different wetland sectors in the present and optimal conditions. Table 8 shows four organizations and 310 fishermen working on the Anzali Wetland in 1996.

The suitable hydrological conditions, such as the depth of wetland water in that year, resulted in the balanced distribution of organizations in the four parts of the Anzali Wetland: the Abkenar organization in the western part of the wetland, the Daheye-Fajr organization in Siahkeshim, the Hendekhaleh organization in the southern region of the central part, and the Nokhaleh (Naghi-Jafari) organization in the eastern part of the wetland. In 2016, while about 11 fishermen were added in the Abkenar district, 48, 26, and 37 fishermen lost their jobs in other wetland organizations, namely the Siahkeshim, Hendekhaleh, and Naghi-Jafari organizations, respectively. This can be directly related to the decrease in the wetland water depth in these areas. The monetary devaluation of any organization can be obtained using the lost opportunity approach. Consequently, reducing the number of people in each organization should be multiplied by the monetary value of creating a job such as fishing. This amount is estimated to be 387,000,000 for fishing in 2016, according to a report by the Guilan Management and Planning Organization (Governor of Guilan, 2017). The amount of lost economic value for each lost fishing job can be obtained from Equation (5):

$$C = (RP_{sk} + RP_{hk} + RP_{nk}) \times VC \quad (5)$$

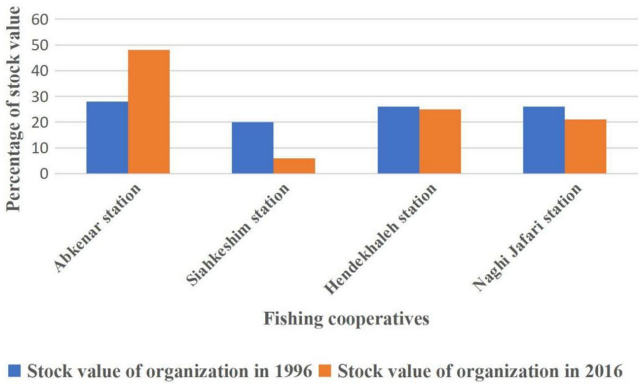
where C is the lost value (opportunity) for eliminating fishing job in different wetland sectors, RP_{sk} is the reduction in the number of people in the Siahkeshim organization, RP_{hk} is the reduction in the number of people in the Hendekhaleh organization, RP_{nk} is the reduction in the number of people in the Nokhaleh organization, and VC is the monetary value to create a fishing job.

As such, the cost imposed on this part of the wetland economic function is

$$\text{Lost cost} = (48 + 26 + 37) \times 387,000,000 = 42,957 \text{ millionI RR.}$$

Also, the indicator of fishing percentage in each organization compared to the total fish caught on the wetland showed that this indicator increased in the Abkenar organization located in the west of wetland from 42% in 1996 to 68% in 2016. However, the indicator decreased in the Siahkeshim, eastern and southern parts of the wetland due to the obvious changes in the hydrological condition, particularly the depth of the wetland water. The result of such a decrease in the depth of water in these areas was the reduced percentage of fishing and decreased the number of fishermen in these areas relative to the total fish caught on the wetland. In fact, it can be stated that the balance existed under the optimal condition in the fishing organizations in different areas has been disturbed, and all organizations, except for Abkenar, have been forced to reduce the number of fishermen for the profitability. The next examined indicator was the percentage of the stock value of organizations and the comparison between the optimal and present conditions. The changes in the stock value of the four organizations over the two study periods are shown in Figure 4. The comparison of the stock value of organizations in 1996 shows that the stocks of all organizations have almost equal value, but in 2016, the stock value of Abkenar Wetland has significantly increased and other organizations, especially Siahkeshim, have largely lost their value.

Figure 4
Comparison of the stock value of organizations in 1996 and 2016 (Guilan Bureau of Fisheries, 2018)



3.3.2. Comparison of bird hunting indicator on wetland margin in present condition compared to target conditions

Another direct value of wetland is the revenue from bird hunting. To determine the devaluation of wetland ecological services, the total number of birds was first analyzed. For the purpose of economic valuation with the market pricing method, the focus was on the halal birds that are hunted by the hunters and have a certain price in the market. The investigation of bird hunting statistics showed that three species of teal, coot, and mallard have the highest hunting number, respectively, and thus can be suitable species for the valuation of the wetland birds. Table 9 shows the number of birds in the present condition and in the target years. As can be seen, the decline in the wetland hydrological conditions such as the reduced water depth, level, and area has a direct relationship with the decrease in the total number of the wetland birds, as the farther the wetland from the optimal conditions, the lower the total number of birds. Obviously, this decrease in population has also affected and reduced the birds of prey on the wetland.

To determine the monetary effects of changes in the ecological conditions by reducing the resulting services provided in this sector, the price of each bird can be multiplied by the difference in the number of birds in the present condition from the optimal and minimum conditions and then determines the reduced monetary

Table 9
Number of fishermen, amount of fishing per year, and fish caught per person in different areas of wetland in present and optimal conditions (Guilan Bureau of Fisheries, 2018)

1996	Abkenar organization (western)	Daheye-Fajr organization (Siahkeshim)	Hendekhaleh organization (central)	Naghi-Jafari organization (eastern and central)	Total
Number of fishermen (person)	132	61	57	60	310
Amount of caught fish (ton/year)	175	81	75	79	410
Fishing percentage of each organization relative to total fish caught	42	20	18	20	100
Stock value (IRR)	130	100	120	120	470
Percentage of stock value	28	20	26	26	100
2016	Abkenar organization (western)	Daheye-Fajr organization (Siahkeshim)	Hendekhaleh organization (central)	Naghi-Jafari organization (eastern and central)	Total
Number of fishermen (person)	143	13	31	23	210
Amount of caught fish (ton/year)	552	50	119	89	810
Fishing percentage of each organization relative to total fish caught	68	6	15	11	100
Stock value (IRR)	16	2	8	7	33
Percentage of stock value	48	6	25	21	100

Table 10
Total number of birds and birds of prey on Anzali Wetland (Guilan Department of Environment, 2018)

Number of bird	Optimal condition (1996)	Minimum condition (2009)	Present condition (2016)
Total number of wetland birds	16,500	112,418	84,324
Coot	37,467	28,655	16,829
Teal	44,646	34,437	28,326
Mallard	25,691	14,689	7985
Total number of birds of preys	107,804	77,781	53,140

Table 11
Comparison of the reduced monetary value of birds of prey in present conditions with target conditions (Guilan Department of Environment, 2018)

	Comparison between current conditions and optimal conditions (1996 vs 2016)			Comparison between current conditions and minimum conditions (2009 vs 2016)		
Bird	Difference in the number of birds in the present and optimal conditions	Bird value (IRR)	Monetary value (IRR)	Difference in the number of birds in the present and optimal conditions	Bird value (IRR)	Monetary value (IRR)
Teal	16,320	35,000	571,200	6111	35,000	213,855
Coot	20,638	30,000	619,140	8812	30,000	264,360
Mallard	17,706	80,000	1,416,480	6704	80,000	536,320
Total			2,608,820			1,014,565

value. Table 10 shows the reduced monetary value of the services on the Anzali Wetland in the present condition relative to the target conditions.

According to Table 11, the distribution of damage in different wetland areas is not the same, as Siahkeshim suffered the most damage. From the economic justice distribution viewpoint for achieving the sustainable development, the wetland has not the necessary balance due to the disproportionate distribution of income in different areas, which was directly caused by the change in the unbalanced ecohydrological conditions, which can also impose unseen and unimaginable costs on the society from the political and social dimensions.

3.4. Conclusion

Although Anzali International Wetland, as a unique aquatic ecosystem in northern Iran, has provided many services in recent years, it has been affected by numerous natural and anthropogenic factors. Since the wetland's name remained on the Montreux List, there is no doubt that its survival is at stake. The hydrological conditions of a wetland play a vital role in the functions of aquatic ecosystems to preserve the ecological values and socioeconomic conditions of the wetland stakeholders. In this regard, the amount of water needed to maintain the ecosystem functions and services was considered in both optimal and minimum conditions for the wetland ecosystem and the associated local communities. Then, the reason for wetland ecosystem loss, in the disputes over water allocation, is the community's and political elites' unfamiliarity with their economic value. Thus, the financial analysis of observed and latent (use and non-use) services of the Anzali Wetland was performed. Besides, this paper calculated the economic value of some wetland ecological services that directly and tangibly contribute to the livelihoods of local communities, taking the principles governing the water resources systems within the IWRM framework into account. Based on the calculations made on the ecological services of the Anzali Wetland, the minimum total value of this wetland based on the 2016 capital value was estimated to be 592,620 million IRR, 39% of which was related to the use values and 61% to the non-use values. Subsequently, to show the possible values in the case of returning the ecohydrological wetland conditions from the present to optimal conditions the calculations were based on the lost values in three indicators (boating, bird hunting, and fishing). The results showed that if the wetland is restored to optimal conditions, 69,050 million IRR would be achieved. The monetary value calculated shows that the changes in the hydrological conditions of the wetland have a great impact on the living conditions of the marginal residents, which are consistent with those of previous studies. (Ayeni et al., 2019; Kamwi et al., 2015; Xu et al., 2015). The examination of the wealth distribution (economic values) in the wetland reveals the severe heterogeneity among the various sectors. It does not imply a specific result from the national perspective. But based on the IWRM principles and the definitions of sustainable development, the Anzali region does not have the necessary balance from the regional perspective. The geographical situation of the case study has a uniform ethnicity, unlike the other wetlands, such as Urmia or Hamoun Hirmand. But this does not eliminate the need for specific social studies to examine the possibility of a disturbed social balance in the area, which could lead to political turmoil and impose unforeseen costs on society. The geographical situation of the case study used in this research is such that it does not have the ethnic complexities found around other wetlands in the world, but this requires special social studies to investigate the possibility of disturbing the social balance of the region, which can lead to political turmoil and incur unsustainable costs. It does not rule out the prediction of society. In this regard, it is suggested that the mutual effects of reducing water resources on wetland services be investigated in detail.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

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Appendix:

Graphical Abstract: