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RESEARCH ARTICLE

The monetary facilities payment for ecosystem services as an approach to restore the Degraded Urmia Lake in Iran

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Abstract
This study analyzed the potential use of Payment for Ecosystem Services (PES) as a strategy for improving water supply management. This study focused on the Siminehroud Sub-basin due to its high importance to the Basin of Urmia Lake (UL). Siminehroud is the second provider of water (by volume) to Urmia Lake. To evaluate the technical and economic feasibility of a PES scheme, the current land use map was extracted using satellite imagery. In addition, the two algorithms of Support Vector Machines (SVMs) and Maximum Likelihood (ML) are used for Landsat images classification, rather than analyzing the relationship between land use and ecosystem services. Then, the most relevant ecosystem services provided in the region were evaluated using the Benefit Transfer Method. In the last step, by designing and implementing a survey, on the one hand, the local farmers' Willingness to Accept (WTA) cash payments for reducing the area they cultivate, and on the other hand, the farmers' Willingness to Pay (WTP) for managing the water consumption were determined. The results illustrated that the WTA program is more acceptable among the beneficiaries. It is also notable that this program needs very high governmental funding. Furthermore, the results of the program indicate that the land area out of the cultivation cycle will gradually increase while the price of agricultural water will also increase.

Keywords Payment for ecosystem services · Economic analysis · Water management · Willingness to pay · Willingness to accept

Introduction

Freshwater is a basic necessity in our daily lives and a critical and scarce resource (Chen et al. 2020; Wang et al. 2019) for economic and social development (Zhong et al. 2022) that is unequally distributed around the globe (Agha et al. 2020). During the last decades, global water consumption has increased to fulfill the demands of the growing population. Meanwhile, climate change is negatively affecting the availability of water in many regions (Chen et al. 2019; Mekonnen and Hoekstra 2016; Sanganyado et al. 2018). The geographical and temporal fluctuations in the demand and supply of water add to the issue of scarcity, to the extent that for at least one month a year, nearly half of the global population encounters extreme water scarcity (Brunner et al. 2019). The essence of global water shortage, in other words, is the spatial and temporal disassociation between freshwater demand and supply (Mekonnen and Hoekstra 2016). The negative consequences of water scarcity are more pronounced in arid regions, where water scarcity is considered one of the most important threats to societies and their

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sustainable development (Mekonnen and Hoekstra 2016; Park 2018). Water scarcity significantly impacts all socio-economic sectors, threatening social stability, agriculture, food security (Augustsson et al. 2021; Daghagh-Yazd et al. 2020; Omer et al. 2020), and the sustainability of natural resources. Therefore, multidisciplinary strategies are needed to manage water resources maximizing human well-being without compromising ecosystem sustainability (FAO 2007; Schiavo et al. 2020).

Iran is located in western Asia, a region characterized by its arid climate. In the last decades, Iran has experienced an increase in population, urbanization, industrialization, and agricultural irrigation. As a result of climate change and its harmful consequences, the region has seen periodic droughts (Shadkam et al. 2016; Delju et al. 2013). Moreover, the country's water shortage is compounded by the mismanagement of inadequate water supplies due to a lack of long-term preparation (Lehane 2014), aggressive dam building, illegal harvesting of water for agriculture, and reckless land use (e.g., deforestation and excessive conversion to irrigated farmlands)(Khatibi and Arjjumend 2019; Malekloo 2019). Rather than addressing these issues at their roots, Iran focuses on merely treating the symptoms, which perpetuates the problem. In other words, Iranian managers usually focus on treating the symptoms of the issue rather than resolving the principal reason (Sanikhani et al. 2018).

On the one hand, while only 15% of the area of the country is cultivated, 92% of the water intake in Iran is accounted for the agricultural sector, while domestic and industrial uses are responsible for 7% and 1% of water consumption, respectively (Faramarzi et al. 2010; Madani 2014; Saatsaz 2020). On the other hand, the heterogeneous distribution of rainfall and runoff in Iran in space and time has led to different approaches to water resources management in different basins (Zargan and Waez-mousavi 2016). A prominent example of Iran's water crisis is the case of the Urmia Lake Basin in northwestern Iran near the Turkish border. Since 1996, the water level of LU has been decreasing and the depth of this lake has decreased from 1270 m in 2016 to about 8 m. This has caused the water of this lake and the soil of the surrounding lands to become super-saline (Daneshyazdi and Ataie-Ashtiani 2019). Due to the severe drought and overuse of the river's water to expand agricultural operations in the basin, water flows feeding UL have been drastically curtailed (Schulz et al. 2020a). As a result, the quality and quantity of water and wetlands in and around the lake are severely affected and endanger the sustainability of ecological functions, which can lead to irreparable damage to the environment and local communities (Alizade Govarchin Ghale et al. 2018). The rivers Zarrinehroud and Siminehroud provide UL with water inputs. These rivers supply about 52% of the water of LU annually. Zarrinehroud river's share is 42%, while Siminehroud river's catchment is the second largest catchment which injects about 11% of water into the lake annually (Feizizadeh et al. 2021). Over the past few decades, agricultural activities within this basin have expanded dramatically (Faramarzi 2012). Consequently, the withdrawal of water from Siminehroud, which has reduced the water inflow into Urmia Lake, has increased dramatically. This is one of the reasons for the present critical state of the lake (Soudi et al. 2017). Iran has a large variety of small and large lakes that have lost their water and dried up during the last few decades, mostly as a result of the existing management (Rahimi Balkanlou et al. 2020). Since early 2000, the UL and other lakes in Iran have lost considerable depth. The key causes for this are the dry environment and changes in water use habits for irrigated farming activities, as well as land flow diversions, groundwater extraction, and lack of adequate water management (Sattari et al. 2020). Many dams have been constructed on rivers flowing into reservoirs since agriculture activities depend on drainage and freshwater supplies (Shirmohammadi et al. 2020). As a result, the cumulative impact of these dams, combined with high groundwater exploitation exacerbated by recent drought periods, has resulted in increased groundwater exploitation and has left Iranian lakes in a critical situation. This has resulted in the gradual alteration of shorelines and the disappearance of natural landscapes (Bijani et al. 2020).

PES arises when the users or beneficiaries of an ecosystem service pay the service providers. PES develops when users or other stakeholders pay the service suppliers. PES is created when customers or other interested parties pay the service providers (Ruggiero et al. 2019). Furthermore, PES stands for payment for environmental services or benefits, which are incentives given to farmers or landowners in return for managing their property to produce some form of ecological service. They are described as a clear method of supplying extra environmental services by making constrained payments to volunteer providers. These initiatives encourage the protection of natural resources in the commercial sector (Guo et al. 2020).

As a result, some global environmental changes, including changes in surface water resources systems, such as rivers, streams, and lakes, may be due to advances in land use and human use (i.e., surface and groundwater use as well as reservoirs) and changes in the landscape. Human activities such as changing cultivation patterns, changing agricultural land use, and over-irrigation have intensified the drought in Isfahan province (Kakae et al. 2019).

As a large hyper-saline lake, UL is a prime example of an environmental disaster in the Middle East in which the effects of climate change and human activities are significant. Although seasonal changes in the lake water level are strongly influenced by atmospheric circulation patterns, it is possible to attribute the reduction in the lake's water level to extensive human activities (Mahmood and Jia 2018), including various dam construction schemes (Nowak and Ptak 2018), over-exploitation of groundwater at a rate higher than the rate attributed to aquifer charging (Jeihouni et al. 2018), highway construction (Parizek 2020), agricultural expansion (Zhang et al. 2020), and irrigation water consumption through inefficient agricultural methods (Karandish 2021). Furthermore, in recent decades, the expansion of urban areas and developed lands in the UL basin is evident. Therefore, human activities and land use change have been the most important factors in reducing the water level in UL (Bakhshianlamouki et al. 2020).

UL drying has led to the depletion of freshwater wetland habitats in the south of the lake, which is an important habitat for native and migratory wildlife (Schmidt et al. 2020). Another effect is the significant interruption of migratory birds' migration cycles (which has altered one of the world's most important migratory birds' flight corridors) (Schulz et al. 2020b). As a result, only UL (Artemia) saline organisms are extinct, which in addition to having special economic value, is the primary food source for migratory birds. Because many species of migratory birds, especially seabirds, use Artemia habitats, adult saltwater shrimp, often carrying live cysts, can be an important part of their diet. Birds can spread cysts between habitats that attach to their feathers or legs from the outside or in their digestive tract from the inside (Frisch et al. 2021). The global growth approach to development is changing the Earth's ecological environment and is creating a set of environmental threats that could jeopardize the economic and political structures of nations (Alizade Govarchin Ghale et al. 2018). As a result, while it is very likely for a governmental party to achieve prosperity, sustained growth would be fraught with dangers if environmental concerns are overlooked (Menton et al. 2020). Disruption of biodiversity in the area, increased salinity, soil degradation, depletion of water bodies, salty dust, and weather changes in the region are all consequences of construction strategies implemented in the UL climate, and they all endanger the region's long-term survival. Then, because environmental concerns are overlooked, environmental sustainability would be questioned (Sharifi et al. 2018).

Fahad and Wang (2020) argued that many people in this industry are clearly facing existential threats as agriculture's vulnerability to water stress and climate change makes farmers vulnerable. Currently, many farmers are still suffering from drought, despite the limited use of water in the UL Basin for non-agricultural purposes. Their capacity to respond to variable conditions seems limited. However, it is vital for the country to adjust its crop and seek solutions to save water (Schmidt et al. 2020). This paper has shown the importance of finding long-term alternatives as soon as possible to mitigate the environmental disasters and provide jobs for the local community. Many recent attempts to rebuild the lake's ecological equilibrium have proved unsuccessful or are hindered by financial restrictions (Schmidt et al. 2020). According to Dehghanipour et al. (2020), there is a lack of organized solutions and a strategy that supports the integration of both ecological and social aspects of water conservation. Many of the world's lakes (such as the Aral Sea, Lake Chad, and Lake Poopó in Bolivia) are on the verge of drying up. UL is a great example of how ecological and social processes are interconnected, and how climate change and human influence will change an entire region's hydrology and biodiversity, with unforeseeable implications for the population (Ženko and Menga 2019). Understanding multiple causal relationships, as well as establishing sustainable resource governance, necessitates a multidisciplinary approach that incorporates science and social insights (Bodin et al. 2019). Slow-start disaster at UL provides an excellent environment for further research into the multiple effects of disaster, the mechanisms of adaptation, and their impact on people living in rural communities across the lake. To prepare for adaptation or mitigation, the following indications in this regard would be useful for stakeholders in other regions of Iran or the Middle East, where many water sources are under water stress, and climate change would place much more pressure on the water supply. A popular approach used in other regions of the world to resolve water problems is the principle of PES (Wang and Wolf 2019). PESs are market-based schemes that aim to achieve environmental conservation and socioeconomic development (Song et al. 2018). These schemes have been increasingly applied globally and have demonstrated considerable positive results (e.g., Brownson et al. 2019; Yost et al. 2020; Yu et al. 2020). Therefore, the implementation of a PES (Payment for Ecosystem Services) scheme in UL, if accompanied by successful results, can be used to manage and rehabilitate other dry lakes in Iran (Forouzani and Karami 2011; Balkanlou et al. 2020).

As for health and provisioning services, which include food/water and profit-generating pharmaceuticals, the focus has mostly been on service provisioning (Suich et al. 2015). This is fundamentally skewed against marketable commodities that can generate cash profits and, as a result, can contribute to economic well-being (Liu and Opdam 2014). Though monetary factors contribute to happiness (Chaigneau et al. 2019), ecosystem services offer a wider spectrum of tangible and intangible benefits (Chan et al. 2011). Depending on the uses of environmental services, these advantages can be useful to people for a variety of reasons and, therefore, can lead to multiple aspects of health (Liu and Opdam 2014). Ali et al. (2020) found that in abiotic ecosystem services, water quality is the most valuable ecological trait. As a result, ecosystems provide many benefits, including regulation of environmental conditions and recreational opportunities, to people in urban areas. Therefore, relative to rural inhabitants, urban households are able to spend more on the conservation of ecosystem services. Sone et al. (2019) argued that the implementation of the PES project in an environmentally protected area reduces soil erosion and saves water consumption. Furthermore, based on an improvement in forest areas and soil management practices such as level terraces, their results suggest that soil conservation practices conducted in the basin increase base flow and also have greater resilience against adverse events such as drought. In another study conducted by Rai et al. (2019), the role of water availability to consumers was examined by PES. Their findings show that the PES scheme has been very effective in the sustainable management of water resources by creating strategies for the fair use of watersheds by communities and the interest of water users in water management. PES is a vital instrument for guaranteeing the sound security of public assets and natural resources, as well as the upkeep and regeneration of degraded ecosystems and associated facilities (Farley and Costanza 2010) (Mombo et al. 2014). Although there are a number of different conceptualizations of PES (for example, Corbera et al. 2009; Ferraro 2008; Jack et al. 2008; Wunder 2015 and 2005), for this work, we use the methodology proposed by Muradian et al. (2010), according to which, PES "redistributes resources by social actors with the purpose of providing incentives to align individual and/or group land use decisions with benefits to society in natural resource management." The literature on PES schemes (Chen et al. 2020) shows that these schemes were often implemented in areas where the natives were pioneers in adopting new technologies. These people are often leading farmers whose ideas and methods are followed by other farmers. According to studies by Farley and Costanza (2010) and Lliso et al. (2020), people who haven't been very clear about their preferences for interface elements and framing will need to maintain their effectiveness. When considering PES designs, it is critical to identify appropriate methods for eliciting indigenous peoples' desires. In another study by Wang et al. (2017), it has been shown that despite the lack of scientific evidence of their efficacy in alleviating poverty, PES schemes were commonly used. Wang et al. (2017) have further demonstrated the advantages PES programs provide for participants. For non-participants, adverse effects have been discovered. The livelihood assets of the participants are specifically significantly strengthened by a number of institutions and policies. Participants are now more able to access natural resources thanks to these institutions, while the rest are now excluded. These institutions further develop and mediate participants' livelihood strategies and sustainable livelihoods. Instead, non-participants are barred from the project and from using natural resources. Changes in resource availability have a detrimental impact on their assets and livelihood plans. The initiative has a negative overall influence on the non-participants' lives due to the project's scant trickle-down benefits and notable negative effects. According to Chinangwa et al. (2017), PES systems can be used to further reduce deforestation. Despite much of the grey literature on PES in many parts of the world, there are significant gaps in the previous academic literature on how the private sector can play a significant role in PES initiatives, especially in developed countries. Chinangwa et al. (2017) claim that the most effective framework for involving the private sector is to introduce PES schemes as a system of corporate social responsibility or in a loan-based manner (e.g., as a requirement to obtain credit for agricultural inputs or eligibility to be negotiated to farm tobacco/sugarcane). Given that the PES plan is being implemented using a novel strategy, this trend is fresh and original. The advantage of this approach over other ones is that it can be used through a questionnaire to assess WTP or WTA stakeholders to protect ecosystem services or for other purposes. In fact, the buyer's maximum numerical value for the environmental products or services received is referred to as WTP, while WTA provides the minimum payment that a provider requires for a certain number of ecosystem services (Li et al. 2018). Therefore, the main goal of this study was to contribute to analyzing and identifying the PES scheme as an instrument to further enhance water resource management. In addition, this study has some practical implications including 1) providing income distribution, 2) economic development and poverty reduction recommendations, and 3) natural resources and environmental management strategies (i.e., flood control and hazard protection, improved water quality, land rights, and resource possession are designated and identified). Furthermore, the findings of this study can help environmental planners and water resource management to recover degraded ecosystems and their services. This study can also be used to create resilience to ecosystem services posed by human threats to other saline lakes. The main goal of the PES program is to enable land managers to use environmentally friendly techniques with respect to ecosystems through economic incentives (Jiangyi et al. 2019). In this work, we aim to analyze the potential use of a PES scheme as an approach to improve water resources management. Therefore, given that PES schemes have been less studied and applied in Iran, the efforts of this study have been focused on answering the following questions:

– Can the implementation of the PES scheme be used as an approach to the management of water resources of the Siminehroud Watershed?

– Can the implementation of the PES scheme help restore the degraded ecosystems of the Siminehroud Basin and at the same time improve the livelihood of the communities living in this watershed?
– Can WTP and WTA be effective in improving the management of water resources in the Siminehroud Basin?

This study suggests the application of the PES method as a novel strategy for managing water resources, taking into account institutional and environmental settings as well as the significance of WTAs & WTPs in managing water resources in all nations experiencing water crises. In addition, this study highlights the consideration of PES as a water cycle management tool, promoting water reuse in water-scarce regions of the world under an economic approach.

Methodology

The UL Basin is located in northeastern Iran. The basin has a surface area of 52,331 km2, and its altitude ranges from 1,236 to 3,732 m above sea level. The annual precipitation average in the basin is 360 mm, and the annual temperature average is 11 °C (Dariane and Eamen 2017). There are 13 main rivers within the hydrological network of the basin, all of which discharge into UL which is centrally located within the basin (Emdadi et al. 2016). UL has been described as “the world's second largest saline lake” (Okhravi et al. 2017), and “the saltiest lake in the world, where life flows in it” (Ghasemzadeh 2017). With a length of 140 km, a width of 55 km, and a depth of 16 m, this lake is the largest lake in Iran (Zoljoodi and Didevarasl 2014). The main water body of the lake is surrounded by freshwater wetlands with high ecological relevance, and 27 mammal species, 212 bird species, 41 reptile species, 7 amphibian species, and 26 fish species have been recorded (Ghasemzadeh 2017). As shown by Mohebbi (2020), the lake is experiencing substantial phytoplankton formation, with thick algae blooms occurring during low salinity years. The lake has been classified by UNESCO as a Biosphere Reserve because of its special characteristics, and it was identified as one of the most important international wetlands in the Ramsar Convention on Wetlands (Emdadi et al. 2016).

The two main rivers, called Zarrinehroud and Siminehroud, supply 55% of the total water discharged into UL (Emdadi et al. 2016). In this study, we have focused on one of these two rivers that is the Siminehroud. The advantage of focusing on the Siminehroud River is that the entire catchment area of the river is located in a single province, making the data collection and comparison process easier. The Siminehroud Watershed is located in the south of UL, in West Azerbaijan Province. This watershed provides 13% of the total water flowing into UL. The length of the Siminehroud River is 200 km, and the area of the watershed is 3,710 km^2 (Fig. 1).

Mapping of current land use

In order to develop the PES schemes to manage water consumption in agriculture in the Siminehroud watershed, it is first necessary to determine the area of agricultural lands in the region. Therefore, the lack of accurate and up-to-date data is due to land use in the Siminehroud Watershed, and a new land use map was prepared using satellite imagery. Satellite imagery has evolved significantly in recent decades, and it is used in various studies with different purposes. One of the most important uses of these images is to extract land use maps. Due to the existence of different sensors that produce images with different spatial and temporal resolutions, the choice of sensor type depends on the purpose and type of research. Landsat satellite imagery is one of the most common and accessible images for classifying and extracting land use

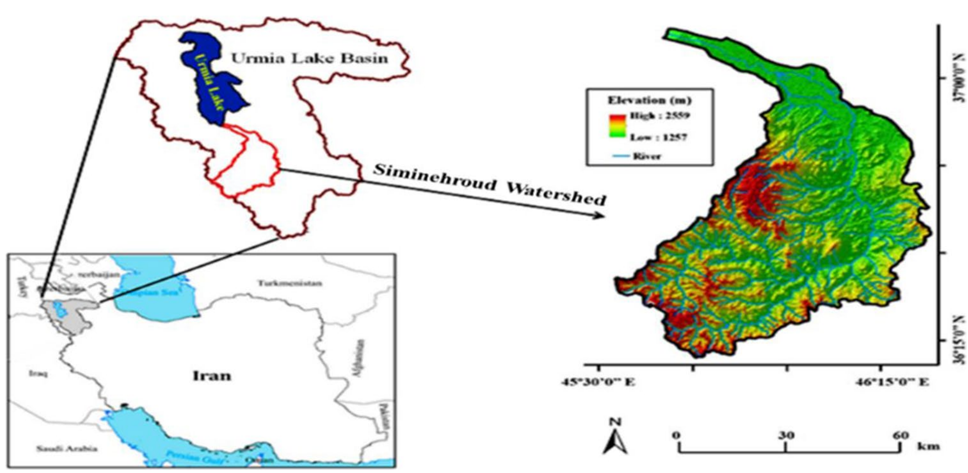


Fig. 1 Location of the area of study

maps. Therefore, in the present study, Landsat sensor images were used, and the images were obtained in April 2014 through the operational land imager (OLI) from the US Geological Survey (https://earthexplorer.usgs.gov/). The classification was performed based on two algorithms including the algorithm for SVMs (Support Vector Machines) in four different kernel types (Linear, Polynomial, Radial Simple, and Sigmoid) and the Maximum Likelihood (ML) algorithm. These two algorithms have been extensively used in the literature for remotely perceived graded imagery (Mountrakis et al. 2011).

As a consequence, a map of land use for the Siminehroud Watershed was produced defining four different classes (residential areas, irrigated farmlands, rain-fed farmlands, and rangelands). Geometric corrections of the images were performed after applying the non-parametric polynomial method and removing inappropriate points, with 29 ground control points and a square root error of 0.34 pixels. After fieldwork, the size of the training samples in the area was determined by considering the ratio of each of the uses. The training set is comprised of pixels per class for each of the four land cover classes. Based on this, 206 training samples were taken for rangeland, 120 for dryland agriculture, 86 for irrigated agriculture, and 48 for residential areas. 70% of training samples were used for classification and 30% of training samples were used to evaluate the accuracy of the methods used. These training points were gathered by a handheld GPS through field studies and Google Earth. In addition, a combination of three common false color bands, including 2, 3, and 4, was used for better classification. Then, their map was prepared and extracted using ENVI 5.3 software. The overall precision and Kappa coefficient were used to compare the classification images and to indicate an accurate process (Banko 1998; Bharatkar and Patel 2013; Bogoliubova and Tymków 2014). The purpose of using the kappa coefficient and overall accuracy in this analysis is to find the most reliable classification algorithm to be able to identify satellite images with high accuracy using that algorithm. The coefficient of Kappa is an indicator of the total matrix consensus and can be computed as follows (Bharatkar and Patel 2013):

$$K = (Po - Pc)/(1 - Pc) \quad (1)$$

where Po denotes the percentage of units that agree with absolute accuracy and Pc denotes the percentage of units that agree with expected probability. Furthermore, the overall precision is known as the error matrix N = (nij) and it can be computed as follows (Gómez and Montero 2011).

$$O^c = \sum_{i=1}^{k} (nij)/|T| \quad (2)$$

where |T| is the number of pixels we are testing.

Economic valuation of UL's ecosystem services

Ecosystem values are indicators of how valuable ecosystem services are to people. Economists estimate the value of ecosystem services to individuals by assessing how much people are prepared to pay to maintain or improve them. Ecosystem values are classified into numerous forms by economists. Use values and non-use, or "passive use" values, are the two main categories. Use values are based on how the environment is really used, whereas non-use values are those that are not connected to how the ecosystem or its services are actually used or even available for use. Use value, then, is the value that results from actually using an item or service (Himes and Muraca 2018). Evaluation of ecosystem services often comprises both monetary and non-monetary evaluation. The two primary methods of financial valuation used to calculate the monetary worth of all the biomass produced by ecosystems are alternative marketing strategy and marketing simulation strategy. In order to establish methods to collect some of these advantages and make them accessible for conservation, valuation can assist identify the conservation beneficiaries and the size of the benefits they receive (Rincón-Ruiz et al. 2019). In this regard, two methods, direct market pricing and conditional valuation, were employed to offer ecosystem services (ES) value. The direct market approach relied on existing markets and prices for valuing the European social survey (Ess). The possible valuation aroused the desire of individuals to pay monetary compensation for the loss of an ES. To this end, in a survey, respondents were asked to express their willingness to use PES to protect UL-supplied Ess. Implementation of a PES scheme from an industrial point of view can be justified only if the costs are lower than the benefits (Hejnowicz et al. 2014). It was therefore appropriate, in the first place, to determine the economic value of UL.

The commercial value of the ecosystem services of UL was calculated based on a study by Brander et al. (2013) using the Benefit Transfer Method (BTM) (Daneshi et al. 2020). According to Brander et al. (2013), the role of three regulatory facilities, namely flood control, water availability, and nutrient conservation, was emphasized. They report on the most important factors in water management in wetlands in the United States, Europe, and a large number of wetlands in developing countries. According to this report, the value of this facility was very distinct in different parts of the lagoon (based on the USD rate). The surface area and the water volume of the Lake were determined in order to utilize the findings of this study for the valuation of UL and to determine the economic worth of each cubic meter of the Lake's water. Thus, the average water volume of the Lake in each hectare was determined by dividing water volume by surface area. The economic worth of water in the UL was calculated using the global average for the value of wetland hectares. The important point is that although the use of the benefit transfer method has many ambiguities and is less accurate than conventional methods of economic evaluation of ecosystem services, due to the lack of accurate information about the provision of ecosystem services in Lake Urmia, it is necessary for our proposed method.

Design and implementation of a survey

A hybrid form of interview and questionnaire was performed to explore the viability of the application of the PES scheme (De-Groot and Hermans 2009; Muñoz Escobar et al. 2013). A questionnaire (annex 1) was developed based on a literature review, consisting of 17 questions that are divided into three sections: (a) general questions about water consumers, (b) assessing respondents' attitude on PES schemes including WTA and WTP questions, and (c) queries related to personal/socio-economic details. The purpose of the survey was to evaluate respondents' willingness to participate in PES programs under hypothetical circumstances. During the interview, the benefits of implementing PES schemes were explained to the respondents, and then the necessity of implementing these schemes was discussed in order to resolve the water crisis in the study area. Finally, their willingness to participate was questioned. Our target group was the rural settlers across the Siminehroud River who are the traditional holders of water rights. All villages having river water rights were initially named, and then farmers in these villages were chosen. There are 12,110 agricultural households that extract water from the Siminehroud river, either directly or indirectly, in 66 villages. We used the Cochran formula (Cochran 1963) as follows to decide the appropriate sample size for the study:

$$n_{0=}\frac{Z^2pq}{e^2} \tag{3}$$

If z is the optimal confidence level's preferred critical value, n is the sample size, and p is the probability, then q is 1-p, e is the optimal accuracy degree, and q is the estimated proportion of a feature that is present in the population. Using the formula, a sample size of 398 individuals was determined. Considering the village distribution in the area, we selected 40 villages using unintentional sampling (also referred to as Convenience Sampling, and sampling is done in a haphazard manner) which is a non-probability or non-random sampling process that involves members of the target group that meet specific performance requirements, such as simple ease of access, proximity, availability at a certain moment, or the desire to participate (Etikan et al. 2016). After implementing the survey, the responses were encoded and then analyzed with the SPSS software. In addition to the descriptive analysis, correlations of the independent variables, including age, education level, the total area of agricultural lands, and the total income, with the dependent variables, including acceptance of cash payments and the reactions of beneficiaries to the increase in agricultural water price, were analyzed.

Accordingly, to chi-square of Pearson was used to examine the relationship between age, education level, the total area of agricultural land, and total income by accepting cash payments. In order to represent participants' association power, Eta and agreement coefficient were used. Pearson correlation coefficient was used to assess the correlation between age, area of agricultural land, and total income, with stakeholders' response to increasing agricultural water prices. In addition, the Kendall correlation coefficient was used to investigate the correlation between education level and stakeholder response to increasing agricultural water prices (Levine and Hullett 2002; Onchiri 2013; Patil 2018; Singhal and Rana 2015).

Results

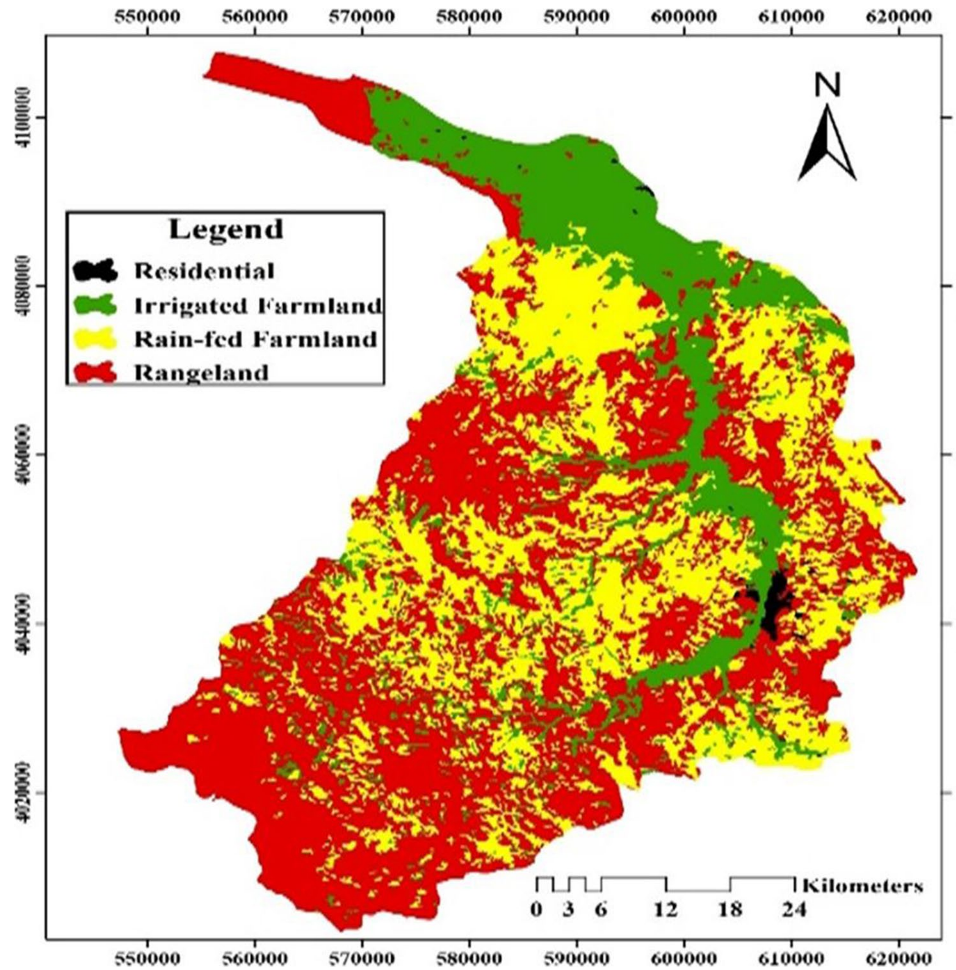
Land use map of the area under study

The results of comparing the accuracy of land use classification maps of the two selected algorithms (SVM and ML) are shown in Table 1. This table shows the average precision as well as the Kappa coefficient. These calculations were performed for each matrix using diagonal elements. Accordingly, the Radial kernel from the SVM algorithm has the highest level of Kappa coefficient (Kc = 90) and the highest overall accuracy (Oa = 94). The results also show that the Linear cores of the SVM algorithm have the lowest level of Kappa coefficient (Kc = 80) and the lowest overall accuracy (Oa = 87). Therefore, this method was chosen to proceed with image classification and the generation of land use maps (Fig. 2). The resulting areas for different land uses identified in the Siminehroud Watershed are 1,934 ha of residential areas, 67,210 ha of irrigated farmlands, 123,387 ha of rain-fed farmlands, and 178,438 ha of rangelands.

Table 1 Differences in accuracy for the Support Vector Machines (SVM) and the Maximum Likelihood (ML) algorithms

Subject	ML	SVM			
		A straight line	The Polynomial	The radial basis function	The sigmoid
The coefficient of Kappa	81	80	89	90	80
Overall precision	90	87	93	94	88

Fig. 2 Land use map of the Siminehroud Watershed



Economic valuation of UL

In a study conducted by Brander et al. (2013), the economic significance of UL was calculated using the Benefit Transfer Methodology (BTM), and it was shown that the mean value of wetland regulating service has been around 16,100 ($/ha/year) for wetland habitat rather than the water itself. The average values of wetland and continental regulator services show the following values: flood management = $6923 / ha / year, availability of water = $3389 / ha / year, and conservation of nutrients = $5788 / ha / year. Among the different services provided by the lake as a wetland ecosystem, flood regulation, water supply, and nutrient recycling are the most important ones that have been valued in economic terms (Table 2).

In order to value UL and its water resources, the total area and depth of water in the lake were calculated for high rainfall periods. Based on the results of the studies conducted by Hosseini and Solatifar (2009) and Mahsafar et al. (2011), the total area of the lake is estimated at 582.200 (ha), and the water volume is estimated to be 31 billion m^3. Therefore, by dividing the lake's area by water volume, the average

Table 2 Averages of wetlands' managing services and averages of continents (Brander et al. 2013)

Variables	The control of flood ($/ha/year)	Supply of water ($/ha/year)	Recycling of nutrition ($/ha/year)	Total value ($/ha/year)
Mean value	6923	3389	5788	16,100

water of the lake is calculated to be 53,246.31 m3/ha. To calculate the economic value of each cubic meter of water in Lake Urmia, the value of each hectare of the lake must be divided by the volume of water per hectare. Based on this, dividing 16,100 by 53,246.31, the economic value of each cubic meter of water in UL is estimated at $0.302.

Survey results

In this study, we compared the potential of two different PES designs. One of the designs is based on cash payments to providers (i.e., farmers) in exchange for reducing the area of land they cultivate. We analyzed this option by gathering information on WTA payment. The other PES is designed as a mechanism for beneficiaries paying for the provision by land managers of a particular service (or an entity on behalf of beneficiaries). We analyzed this option by gathering information on farmers' WTP. It is important to note that the same samples were used to complete the WTA and WTP questionnaires. Taking into account the vital position of the lake in the area and the negative effects of its drying on local communities on the one hand and the public ownership of natural resources and wetlands in Iran on the other hand, the government is responsible for providing financial support for the implementation of the program.

Descriptive information obtained from the survey

Descriptive analysis of the questionnaires showed that the majority of respondents are between the ages of 36 and 50, which is equivalent to 34.67% of the total respondents, while the average total age of the respondent is equal to 53.06 years. In terms of education level, the majority of respondents (46.73%) were in primary school or lower levels. This is while 98.49% of the respondents were men. The majority of producers, according to the findings of the respondents' annual income survey (41.21%), have an annual income of less than $150, while the average annual income from agriculture is $992.3. The average irrigated farmlands of the respondents are 3.37 (ha), which is the highest amount compared to rain-fed and orchard farmlands. On the other hand, the average rain-fed and orchard farmlands owned by the respondents are 0.61 and 0.27 ha, respectively. Table 3 displays the descriptive outcomes of the respondents' socio-economic knowledge.

Farmers' WTA for reducing the cultivated area

The participants were asked to indicate their willingness to accept cash payments from the government in exchange for reducing the area under cultivation. As a result, 55.5% of the respondents were willing to accept the proposal, of which 2.5% were willing to reduce their under-cultivation lands by less than 49%, 10.3% were ready to reduce their cultivation lands by 50–99%, and 42.7% were ready to stop farming on their lands completely. Therefore, based on these results, on average, 50.6% of the total agricultural lands and orchards in the Siminehroud Watershed could be included in the proposed scheme, and they could be removed from the ongoing agricultural activities through cash payments.

Furthermore, it is important to mention that 44.5% of respondents refused to be paid in this program. The main reasons for this are expressed as beneficiaries' dependence on land and farming activities (26.4%), not having an alternative occupation (8.5%), perennial farming and orchards (4.3%), distrust of the government (4/0%), and need for fodder for their livestock (1/3%).

The results of Table 4 show that there are two types of cultivation activities in the region which include farmland and garden. A total of 11 types of crops are cultivated as arable lands and three types of crops are cultivated as orchards. The highest share of cultivated lands (19.38%) is related to wheat with 25,667.50 ha of cultivated area, and the lowest

Table 3 Descriptive results of respondents' socio-economic information

Socio-economic variables	Groups	Frequency	Percent	Average
Age group	35 or lower	56	14.07	53.06
	36–50	138	34.67	
	51–75	111	27.89	
	76 or higher	93	23.37	
Education level	Primary school or lower	186	46.73	-
	High school	153	38.44	
	Bachelor's degree	31	7.79	
	Master's degree or higher	28	7.04	
Gender	Male	288	98.49	-
	Female	10	1.51	
Income	$1150 or lower	164	42.21	2800.66
	$1151–2300	93	23.37	
	$2301–3450	35	8.79	
	$3451–4600	51	12.81	
	$4601–5750	19	4.77	
	$5751 or higher	36	9.05	
The amount of agricultural land	Irrigated farmlands	-	-	3.37
	Rain-fed farmlands			0.61
	Orchards			0.27

Table 4 Area of different crops' cultivation land in the Siminehroud Watershed

Land use type	Crop type	Percentage share of cultivated lands	Cultivated area in the basin (ha)
Farmland	Wheat	38.19	25,667.50
	Sugar beet	21.15	14,214.92
	Alfalfa	16.76	11,264.40
	Barley	9.34	6277.41
	Corn	2.47	1660.09
	Tomato	2.20	1478.62
	Beans	1.65	1108.97
	Vegetables	1.10	739.31
Garden	Apple	5.22	3508.36
	Grape	1.37	920.78
	Peach	0.55	369.65
Total		100	67,210

share is related to vegetables (1.10%) with 739.31 ha. The highest share of gardens (5.22%) is related to apple with 3508.36 ha of cultivated area, and the lowest share is related to peach (0.55%) with 369.65 ha. Thus, the land under cultivation of each crop was calculated by increasing the percentage of cultivation of each crop in the gross water level of Siminehroud Watershed (Table 4).

To calculate the needed costs for cash payments to beneficiaries, the per hectare net income for each cultivated product has been calculated based on the information about the price of each product, land productivity, and related expenditures obtained from Iran's Ministry of Agricultural Jihad. According to this information, the production cost for all crops included about 40% of the total income in 2016. This figure is estimated at about 25% of the total income for garden products. Table 5 shows the annual net income of cultivated crops in the Siminehroud Watershed. These results show that the highest annual net income of various crops in the watershed is related to sugar beet with an average of 64.45 tons/ha and \$3123.346 net income, and the lowest is related to beans with an average of 1.13 tons/ha and \$573.692 national net income. These results also show that the most important crop is the apple orchard with 27.82 tons per ha per year and a net income of \$ 6420.

Then, the National Water Resources Development Program of Iran (NETWAT) (Mirzaei et al. 2019) evaluated all crops, which need water for growth, in the study area (irrigated crops) according to the irrigation method and its efficiency. Based on the collected data from the Ministry of Agricultural Jihad, the productivity levels of rain-fed, irrigation, and dropped agriculture are about 40, 75, and 90, respectively. According to the results of the questionnaires, only 13.86% of the lands of local farmers are equipped with sprinkler systems, and the remaining 86.14% of them are irrigated traditionally. Then, the average water consumption per product was calculated in the present situation for the sake of comparison between traditional and pressurized water consumption (Table 6). The study of the average water consumption of different agricultural products in the Siminehroud Watershed shows that the highest water consumption is related to alfalfa with an average water consumption of 16,017.35 m^3/ha, and the lowest is related to

Table 5 Annual net income of different crops cultivated in the Siminehroud Watershed

Form of land use	Form of crop	Mean of crop yield (ton/ha)	Price per kilogram (\$)	Total income (\$)	Total cost (\$)	Net income (\$)
Farmland	Wheat	4.66	0.404	1881.923	752.769	1129.154
	Sugar beet	64.45	0.081	5205.577	2082.231	3123.346
	Alfalfa	8.92	0.135	1200.769	480.308	720.461
	Barley	3.67	0.3	1101	440.4	660.6
	Corn	14.42	0.3	4326	1730.4	2595.6
	Tomato	43.46	0.097	4178.846	1671.538	2507.308
	Beans	1.13	0.85	956.154	382.461	573.692
	Vegetables	13.51	0.269	3637.308	1454.923	2182.385
Garden	Apple	27.82	0.308	8560	2140	6420
	Grape	15.53	0.461	7167.692	1791.923	5375.769
	Peach	6.25	0.269	1682.692	420.673	1262.019

Table 6 Average water consumption of different agricultural products in the Siminehroud Watershed

Land use type	Crop type	Annual water requirement (m^3/ha)	Water consumption in traditional irrigation method (m^3/ha)	Water consumption in pressure irrigation method (m^3/ha)	Mean water consumption (m^3/ha)
Farmland	Wheat	2730	6825	3640	6383.56
	Sugar beet	6500	16,250	8666.66	15,198.94
	Alfalfa	6850	17,125	9133.33	16,017.35
	Barley	1990	4975	2653.33	4653.21
	Corn	4380	10,950	5840	10,241.75
	Tomato	6660	16,650	8880	15,573.09
	Beans	2910	7275	3880	6804.45
	Vegetables	2740	6850	3653.33	6404.94
Garden	Apple	5910	14,775	6566.67	13,637.32
	Grape	5260	13,150	5844.44	12,137.45
	Peach	6410	16,025	7122.22	14,791.07

barley with an average water consumption of 4653.21 m^3/ha. Peach also has the highest water consumption per hectare, among garden products (14,791.07 m^3/ha).

Having the net income and average water consumption of each product as well as the financial burden for each cubic meter of water, the cost of implementing the PES system in the form of a monetary payment was calculated (S-1). Among farmland products, vegetables have the highest ($0.341) and alfalfa has the lowest ($0.045) amount of needed payments per cubic meter for water conservation, while among horticultural products, apple has the highest ($0.471) and peach has the lowest ($0.085) amount of needed payments per cubic meter for water conservation.

After estimating the approximate value of UL water which is 0/302 dollars per cubic meter, the figures of Table 6 show that the needed cost to provide cash facilities for the farmers of the three products (vegetables, apple, and grape) is more than the calculated value of the Lake, and this value is less than the value of the lake for other products.

In order to extrapolate the results of this survey to a broader scale of the Siminehroud Watershed, the mean cost of implementing a cash payment scheme, considering the cultivation percentage of each product from the total garden and crop cultivation (Table 4), is calculated. The mean cost of implementing a cash payment scheme to prevent the practice of agricultural activities is 0.178 USD per cubic meter of water in the basin. Therefore, according to the approximate value of the lake water which is $0.302, the Benefit–Cost Ratio for implementing this program will be 1.70 USD. In other words, the implementation of the PES in form of cash payments in the Siminehroud Watershed is economically justified. Furthermore, if the program is implemented, the amount of water that falls into the lake will be equal to the total unused water for different products in the basin.

According to the presented results in S-2, the total water consumption for agricultural activities in the Siminehroud Watershed is 706,337,310 Cubic Meters (m^3). This volume of water is saved and flows into the lake if all owners and farmers are paid in cash. It is important to note that according to the responses of respondents, on average, only 50.58% of the total agricultural lands of the basin can be put away from cultivation practices. For that reason, the total annual water which flows into UL is about 359.2 million cubic meters in the case of annual cash payment, and the financial burden for implementing this program in the total area is 63,884,421 US dollars.

Farmers' WTP by increasing agricultural water price

On analyzing the responses to questions about the agricultural water price, it was observed that only 65.83% of them pay water price to the local water company, and that their average payment is 47.31 USD per ha. In addition, to examine the retort of respondents to any change in the price of agricultural water, they were asked whether they would change their area under cultivation if they doubled, tripled, quadrupled, and quintupled their water prices. How will a spike in water prices cause them to abandon all their farming activities? Assessing the respondents' answers showed that among the respondents who pay the water price, 20.61% of them, on average, will not cultivate 97.96% of their lands with a twofold increase in water price. Furthermore, 17.94% of them will not cultivate 96.81% of their lands by tripling the water price, 7.25% of them will not cultivate 92.95% of their land by four-fold the price, and 1.53% of them will not cultivate 100% of their lands by quintupling the water price.

It is important to note that 52.67% of the respondents did not have any reactions to the hypothetical increase in water price and said that they would not stop cultivating under any circumstances (S-3). In total, by doubling, tripling, quadrupling, and quintupling water prices, 8.33%, 14.42%, 17.91%, and 18.21% of the total beneficiaries will stop their agricultural activities.

Furthermore, with 67,210 (ha) of croplands and orchards in the basin, doubling the price of water will result in a 5598.59 (ha) decrease in cultivated areas. The declines in cultivated lands caused by tripled, quadrupled, and quintupled rates of water prices are estimated to be 9691.7, 12,037.3, and 12,238.9 (ha), respectively. According to the percentage share of cultivated lands in Table 4 and also the average water consumption per hectare for each type of cultivation in Table 6, the average water consumption for all crops is estimated at 10,509.38 m3/ha per year. Therefore, it can be said that a twofold, threefold, fourfold, and fivefold increase in the price of water will cause significant declines in agricultural water consumption which would be 58,837,898 m^3, 101,853,840 m^3, 126,505,012 m^3, and 128,624,024 m^3, respectively.

Correlation analysis of social characteristics of beneficiaries by PES acceptance

As S-4 shows, there is a correlation at the 99% level between the acceptance of cash payments, age, the total area of agricultural land, and total revenue, but the strength of this association (as seen in S-5) has the highest overall income. Pagiola et al. (2010) divide the factors that may persuade a family to take part in PES programs into 3 categories: factors that affect the eligibility of a family that depends on the targeting of the programs, factors that affect the tendency of the families to take part in programs, and factors that affect their ability to take part in these programs. For this reason, in this study, the acceptance of cash payments is more among the farmers with more incomes. The reason could be the fact that farming for beneficiaries with lower incomes is subsistence, their purpose is to resolve their families' requirements, and they offer their surpluses to the markets. If they are paid to stop cultivation, they are forced to buy their own product at a higher price, so their acceptance is less than the acceptance of people with higher incomes. Furthermore, there is no considerable correlation between education level and the acceptance of cash payments.

S-6 shows that there is no considerable correlation between age, education level, and total income and the reactions of beneficiaries to the increase in agricultural water price, but it is correlated with the total area of agricultural lands negatively and the paid water price directly, at 99% level of confidence. It means that the reactions of the people having more agricultural lands to water price increase are tougher, and they will not cultivate their lands by low water price increases, but the reaction of the people who pay more for water is slighter, and they will not stop cultivation even if the water price increases dramatically. These results are consistent with the findings by Aljerf (2018) which states that with the increase in water prices, the area under cultivation of crops will be significantly reduced. Considering that, according to the legislation of Iran, orchard men pay more for water, these facts can be related. Therefore, their mild response to the rising water prices can be due to two reasons: First, the income from horticultural products is higher than that of farmland crops, which would not have a significant effect on their income. Second, the fruiting of fruit trees in gardens lasts for several years, and they will not easily refuse to use their gardens if the water price increases.

Discussion

In this research, two PES schemes are proposed to rehabilitate UL with the help of water exploitation of the Siminehroud Watershed. These schemes include cash payments to beneficiaries for cultivation reduction in the form of WTA and increasing the paid water price of farmers in the form of WTP. Assessing the farmers' WTA for reducing cultivated areas showed that the majority of farmers want to participate in this program and are willing to refrain from cultivating all or part of their lands in order to help revitalize UL. The results showed that if such a program is implemented, about 360 million cubic meters can be added annually to the entrance of UL through the Siminehroud river basin, which is a high amount due to the small size of this basin. Furthermore, if this program is implemented in other UL sub-basins, the amount that can provide the basis for the revitalization of UL will be very high. The results show that the use of PES plans has a higher economic justification than cash payments for water consumption in farms. Therefore, considering the efficiency, acceptability, and economic justification of this plan, it is suggested that this program has a higher priority in the implementation of PES than the plan to increase the price of agricultural water. These findings are consistent with the findings of Nyongesa et al. (2016) who measured the annual willingness to consider the payment and expense of using PES to restore natural ecological resources in the watershed of Lake Naivasha.

Economically, the results of the WTA analysis presented that with a benefit to cost ratio of more than 1, this plan has a high economic justification. It is also notable that this program needs very high governmental funding, but as the results showed that UL's importance is even higher than the value of the required cost to implement these programs, paying these costs is economical. In UL economic evaluation, only 3 main functions of the lake have been considered, and if other unique functions of UL are considered, its value will be much higher (Abbaspour and Nazaridoust 2007). These observations are in full harmony with the outcomes of Li et al. (2018). From the viewpoint of local rural families, they looked at the costs of two PES programs including WTA for agriculture and forestry and WTA for fisheries. In Miyun Reservoir Catchment, China, the economic justification of these schemes has also been calculated (Li et al. 2018). Their results illustrated that these schemes have economic justification.

Analysis of the results of the WTP evaluation of farmers with increasing agricultural water prices showed that the area of land leaving the cultivation cycle gradually increases and agricultural water prices also increase. However, the slope of this increase has a decreasing trend which shows that water is a tensionless good for the farmers in the basin because by increasing water price, its demand decreases. These findings are similar to those of Abdulkarim et al. (2016) who looked at the paying of farmers for water irrigation in North West Selangor, Malaysia, and the results of Amponin et al. (2007) who investigated the domestic water users' WTP for watershed protection in Tuguegarao City, the Philippines. The results of both studies showed that people have a high amount of WTP, which contradicts the results of the present study.

The point to consider is that, although the implementation of a WTP program can reduce the area of cultivated lands and agricultural water consumption to some extent, and thus help revitalize UL, it seems that the implementation of such a plan for the following two reasons cannot be successful in the study area: 1) According to the results, farmers did not welcome the implementation of such a plan. Given that one of the most important requirements for the implementation of any scheme, including PES, is the participation and support of the indigenous people of the region and given the low public acceptance of the WTP schemes, its implementation cannot be successful. 2) This program imposes a lot of costs on farmers, which may lead to the dissatisfaction of the beneficiaries and the deterioration of their economic situation. Kronenberg and Hubacek (2013) believe that PES is an appropriate tool to assure the conservation of the global ecosystem, and it is able to reduce poverty in areas containing rich ecosystem services and reservoirs. Therefore, although PES is not a designated tool for poverty reduction, it provides livelihoods for indigenous peoples, especially those living in rural areas, by paying cash and providing other benefits to the participants (Andrew and Masozera 2010; Pagiola et al. 2005; Rosa et al. 2003; Pagiola and Platais 2002). It should also be noted that the implementation of such a scheme can confront society with new social problems such as water theft. On the contrary, it may be assumed that PES users will be more likely to conserve and manage water resources since they would be charged for their usage. Nielsen-Pincus et al. (2017) believe that through targeted communication, managers can relate protection measures to the landscape, which is important to people, affect the attitudes of PES buyers, and thus potential financial support for PES and other protection programs. In other words, as the hydrological benefits of PES schemes become apparent, farmers accept that these schemes will rehabilitate watersheds, which affect their water resources.

Finally, among the two PES programs examined in this study, cash payments to farmers are more acceptable and welcomed among stakeholders, provided that, according to the definitions of the PES plan, it is a voluntary exchange. Another key condition for its implementation is public acceptance and social attention to the protection of natural resources. Therefore, considering the welcome of local stakeholders, the possibility of its implementation is technically acceptable. Finally, it can be concluded that with the increase in water prices according to the regulations, the necessary support for the implementation of this plan is still needed, because paying money to farmers instead of charging will always be the preferred option for them.

Conclusion

This study attempted to answer how the implementation of a PES scheme could be an approach to restoring the degraded UL in Iran. At the moment, the problem of drying UL has become a national and even international challenge. Hence, both domestic and foreign governmental and non-governmental organizations are looking for a solution to this critical problem. Therefore, this study contributes to analyzing the potential use of a PES scheme as an approach to improve water resources management.

As shown by the results of this study, the PES schemes can be effective in this regard and can provide the conditions for UL's revitalization. However, the important point is that strong political, economic, and managerial structures are needed for the successful implementation of these plans. These structures are among the basic requirements of a PES scheme, in such a way that without having appropriate social, political, and even economic structures, the chances of achieving the expected results are very low. These structures help run and manage this scheme without failure. More importantly, there is no record of the successful implementation of PES schemes in Iran. Therefore, according to the good results of this study, it is suggested that the government and non-governmental organizations of Iran, by creating the necessary infrastructure and social and political organizations, provide the necessary ground for the successful implementation of PES projects as soon as possible. These schemes should be piloted in UL's sub-watersheds so that, if effective, they can be used to rehabilitate other lakes in the region, especially in Iran. A very important point is that cash payment to farmers, although acceptable to farmers and economically justifiable, can create problems, especially in rural areas. One of these problems is the unemployment of people who were engaged in agriculture before the PES project, and part of their unemployment can lead to social problems (e.g., economic problems, poverty, and food insecurity). In addition, the wider the implementation level of such a project, the more likely it is that the community will face a shortage of some strategic agricultural products, such as wheat and barley. In this case, in addition to providing direct costs for the implementation of such a program, the government must allocate a separate budget for the import of these strategic products in order to compensate for their shortage. In any case, given the extraordinary human and environmental importance of UL, spending such costs seems reasonable and justifiable.

Policy implications

Planning (the development of planning and management plans and policies) is an important and frequently required instrument for supporting and improving the organizational management of the PES project. Planning enables one to 1) identify the current level of water resources, as well as tensions and expectations about their usage, develop visions, create objectives and targets, and therefore orient operational management; 2) determine the existing state of water resources, as well as conflicts and expectations surrounding their use, and then build visions, set goals, and targets to guide operational management; 3) arrange policy-relevant research and citizen participation in a system; and 4) in particular during times of stress, enhance the level of authority, public acceptance, and even support for how resources would be allocated or handled. Additionally, a management plan or agenda will act as a point of agreement for managers and partners, facilitating easier collaboration, negotiation, and coordination. A management plan or agenda will also serve as a point of agreement for managers and partners, allowing for smoother cooperation, negotiation, and coordination. The most recent occurrences are the result of two trends: (a) broad recognition of the necessity for a bottom-up participatory approach to planning, management, and decision-making and (b) growing concern for environmental preservation. PES has had a lot of support from legislators in recent years, and this strategy has yielded a lot of positive benefits. PES seems to have economic incentives to further use ecosystem resources rather than other instruments. Overall, it can be argued that implementing various PES schemes to control water supplies in the Siminehroud Basin increases productivity and can be applied effectively. As a final point, it can be said that among the two PES schemes examined in this study, the cash payment to farmers is more acceptable and welcoming among the beneficiaries, provided that, according to the definitions, the PES plan is a voluntary exchange, and provided that one of its main conditions to implement is public acceptance and social concern in natural resources conservation. Therefore, considering the welcome of local stakeholders, the possibility of its implementation is technically acceptable. In the end, future research should evaluate topics, study economic instances in water resource management, and conduct economic modelling using well-designed WTA and WTP surveys that follow performance requirements.

It is also suggested that the possibility of implementing other PES projects in the UL region with the aim of managing water abstraction from wells and springs in the region as well as managing water consumption in industry and drinking water be studied.

Appendix 1 Questionnaire used in the present study

Questionnaire of Payment for Ecosystem Services (PES)

(For local communities)

Date:	place:	Q. Number:

I am **Alireza Daneshi**, M.Sc. student of watershed management sciences and engineering at Tarbiat Modares University, currently doing research under the title of **"The Feasibility of Monetary Facilities Payment for Ecosystem Services as an Approach to Restore the Degraded Urmia Lake in Iran".**

Your participation in this survey is completely voluntary. Although you do not have to answer every question or complete the survey or interview, we could greatly benefit from your full participation, and we appreciate your time and effort. It should take about 10 minutes to complete the questionnaire, and your answers will remain confidential. We do not know your names and your names are not included on our mailing lists, and your comments are never connected to your mailing address. You will be helping us out a great deal by offering your thoughts and viewpoints. This knowledge would not be connected to any of your data and your privacy is still secured.

Part One: General Inquiries Related to the Water Users

1- Describe the area under cultivation of your agricultural products separately:

a) Irrigated farmlands .... ha b) Rain-fed farmlands .... ha c) Orchards .... ha

2- Describe the type of cultivation, the area of each, and the amount of harvest from each in the last crop year:

Type of land	Type of crop	Area (ha)	Amount of harvest from each in the last crop year (tone/ha)
Irrigated farmlands			
Rain-fed farmlands			
Orchards			

Part Two: Assessing Respondents' Attitude on Payment for Ecosystem Services (PES)

a) WTA questions

3- Has the drying up of Urmia Lake affected your agricultural activities?

☐ Yes

☐ No

4- Do you want to cooperate with the government and NGOs to prevent the drying up of Urmia Lake?

☐ Yes

☐ No

5- If the government were to provide you with facilities in exchange for reducing water abstraction from the Siminehroud River, what would you prefer these facilities to be?

☐ Monetary Facilities

☐ Non-monetary Facilities

6- If the government pays the equivalent of irrigated farmland revenues, are you willing to give up farming on part of your irrigated farmlands?

☐ Yes, how many hectares? .... (ha)

☐ No

b) WTP questions

7- Do you pay any water prices to the government to meet your water needs?

☐ Yes, how much? .... ($/ha)

☐ No

8- A **twofold** increase in water price may lead you to leave how much of your irrigated farmlands?

.... (ha)

9- A **threefold** increase in water price may lead you to leave how much of your irrigated farmlands?

.... (ha)

10- A **fourfold** increase in water price may lead you to leave how much of your irrigated farmlands?

.... (ha)

11- A **fivefold** increase in water price may lead you to leave how much of your irrigated farmlands?

.... (ha)

12- A more than **<u>fivefold</u>** increase in water price may lead you to leave how much of your irrigated farmlands?

.... (ha)

13- How much increase in the price of water may lead them to leave all their agricultural activities? ....

Part Three: Personal / socio-economic data

14- How old are you?

□ 35 or lower

□ 36-50

□ 51-75

□ 76 or higher

□ Prefer not to answer

15- What is your gender?

□ Male

□ Female

□ Prefer not to answer

16- What is the highest level of education you have completed?

□ Primary school or lower

□ High school

□ Bachelor's degree

□ Master's degree or higher

□ Prefer not to answer

17- What is your annual household income level? Please specify. ....

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Data availability Raw data were generated at Agricultural Sciences & Natural Resources Department of Watershed Management Sciences and Engineering, Gorgan University. We confirm that the data, models, or methodology used in the research are proprietary, and derived data supporting the findings of this study are available from the first author on request.

Code availability None.

Declarations

Ethics approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee.

Consent to participate All authors consent to participate in this paper.

Consent to publish All authors have read and agreed to the published version of the manuscript.

Conflicts of interest We 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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