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Wetland Zoning to Establish Land Conservation Using MCE Method (Case Study: Parishan Wetland, Iran).

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ABSTRACT

Wetlands with high biomass production and water storage, in addition to supply a part of the food and water required for local people, impose positive effects on their economy, customs and culture. On one hand, migration of different species of birds to the wetlands and on the other hand, high diversity of flora in different plant categories emphasize on the need of proper planning for conservation of biodiversity in the wetlands. Wetland zonation to protect the biological resources is one of the basic steps in this respect. Parishan Wetland with an area of 4800 ha, is one of the permanent freshwater wetlands in Iran, located 12 Km away from the southeast of Kazeroun City in Fars Province. The basic purpose of zoning Parishan Wetland is to conserve biodiversity and develop ecotourism in the region with regard to environmental and ecosystem aspects. Multi Criteria Evaluation (MCE) has been used for this purpose. After identifying the available resources, two protected and recreational zones were identified. The recreational zone, in turn, was divided into a central zone and two proposed zone (1 and 2). All three recreational zones were located on the northwest of Parishan Lake and the rest of the lake area was assigned to conservation zone. The obtained results indicated that, conservation zone is broader than recreational zones.

Key words: Zoning, Parishan Wetland, Conservation, Multi criteria evaluation.

Introduction

Earth in its evolutionary history has been witnessed five mass extinctions. The first mass extinction occurred in "Ordovician period" (500 million years ago) which led to the annihilation of half of animals [1,2,3]. According to scientists, population growth and expansion of human habitats is the last mass extinction event so that in the last two centuries, the human population has grown from 1 billion to 6 billion people and the extent of human habitats has been spread from 10 to 25% [4]. This process results in increasing consumption of natural resources and biodiversity loss. The new concept of conservation of natural and living resources is currently emerged and conservation in the form of protected areas is a result of the planning and environmental studies in the last century [5,6,7,8]. Nowadays, following sustainable development, extensive planning is done to increase the usage of protected areas. Unlike the previous conceptions, world is trying to modify the nature island concept of the protected areas to reveal the capabilities of such areas [9,10,11]. According Ramsar Convention, "wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6m" [12]. Based on the mentioned definition, Parishan is recorded among the international wetlands. A number of researches have been carried out in the field of wetland zoning in the world which some of them are here mentioned. Paulumi *et al*., applied Geographic

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Information System (GIS) and Multi Criteria Evaluation (MCE) techniques to zone Bengal Wetland in southern India. Tamia *et al*., used GIS technique for zoning the wetlands to protect them. Vaudour *et al*., [20] condected a research on digital zoning of South African viticultural terroirs using bootstrapped decision trees and multitemporal SPOT images. Schulte-Hostedde *et al*., examined wetland conservation efforts in Ontario. Xiao *et al*. [22] investigated changes in landscape patterns of Sichuan Ruoergai Wetland National Nature Reserve. Boyes *et al*., [23] proposed multiple-use zoning scheme for the Irish Sea by means of GIS. In 2000, Lin presented GIS-based information flow in a land-use zoning review process. In 2010, Fernández and Lutz applied GIS and multicriteria decision analysis to present urban flood hazard zoning in Tucumán Province, Argentina.

It is the first time in Iran that Parishan Wetland is zoned using GIS and MCE techniques. The study ahead focuses on zoning Parishan Wetland in order to specify protection zones, enhancing the public awareness and regional authorities on the outcomes of unstable exploitation. Thereby, dynamic and sustainable exploitation of the wetland will be possible to present and future generations.

Materials And Methods

The Study Area:

Parishan Lake is situated between longitudes 51°44′50″–51°51′25″ E and latitudes 29°28′40″–29°32′30″ N. It has a height of 820 m above sea level. The lake catchment area is 266.5 km^2. The wetland with an area of 4,800ha is located on 12 km southeast of Kazeroun City, in the southern border of Zagros Mountains. Apart from the northwest part covered by canebrake, Parishan Lake is surrounded by arable lands and numerous villages at all directions. The lake water is almost supplied by annual rainfalls. The lake area reaches its maximum level in May. It can be said that this lake is one of the most beautiful freshwater lakes of Iran. Considering the beautiful natural landscapes, biological diversity, density of different species of migratory birds, recreational and educational facilities, easy access to multiple features, this region can be used as a natural laboratory by relevant experts. The situation of Parishan Wetland is shown in Figure 1 . Currently, the area is managed traditionally and every day, it is degraded more than ever before. Thereby, presenting a "Management Plan" seems necessary for the mentioned wetland.

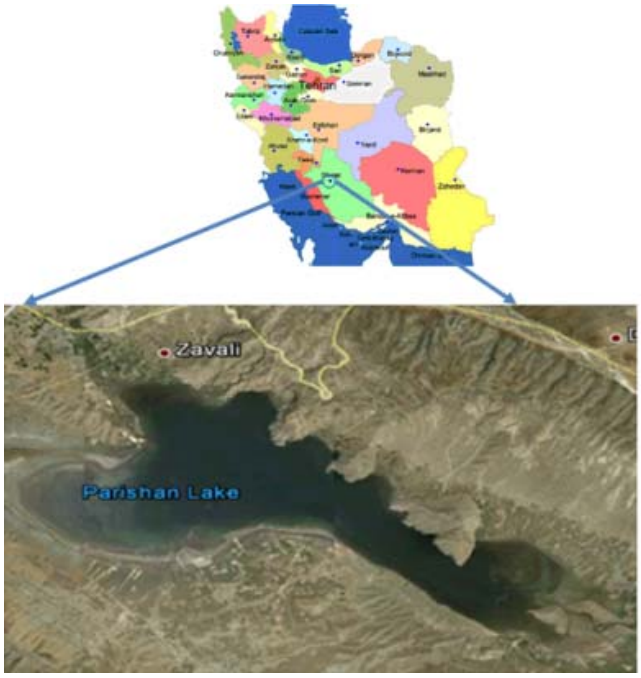

Fig. 1: Position of Parishan Wetland in Fars Province and Iran.

Therefore, the study ahead focuses on zoning the study area. The output would be applied as a background for the comprehensive management plan of the wetland. It is worth noting that the wetland has been selected as a protected area due to the existence of the important habitats, rare species, endangered animals and plants and other important characteristics. The best way for sustainable development of the area, is nature conservation which has the highest priority among the existing land uses. Conservation is applied at the species, ecosystems, biodiversity and landscape.

Endangered Species:

According to studies conducted by Department of Environment (DOE) as well as laws and regulations in Iran and international organizations such as IUCN and CITES, a number of plant and animal species has been introduced as rare and valuable species due to population decline, habitat destruction, uncontrolled hunting and other environmental factors (Table 1).

Table 1: Endangered rare and valuable species in Parishan Wetland (DOE, year?

Plants	Wildlife
Crocus Haussknechtli	*Ovis orientalis*
Zataria moltiflora	*Ursus arctos*
Nepeta Glomeratosa	*Panthera pardus*
Achillea milifolia	*Rhinolophus Ferrume huinum*
Echillea eldocentra	*Rhinolophus Euryale*
Pyrus syriace	*Pelecanus crispus*
Juniperus exelcior	*Ciconia nigra*
Amygdalus orientalis	*Branta roficollaca*
	Aohuila heliacal
	Falco naumanni
	Oxyura leucocephala

Since, the species listed in Table 1 are endangered in the region; to eliminate the adverse effects of mentioned above factors, no choice remains except to use multilateral methods with emphasis on nature conversation to protect region values.

The Research Methodology:

In this study, to determine the Conservation Zone of Parishan Lake, the region was initially zoned base on ecological capabilities and the current buffers using Multi-Criteria Evaluation method which is briefly called "MCE". World Commission on Protected Areas (WCPA) has presented particular managerial procedures and frameworks to protect the areas categorized in the fifth IUCN classification zones (terrestrial and marine landscapes). Actually, the purpose of these guidelines is to promote the management of these areas. Table 2 gives IUCN criteria for determining conservational zones.

Table 2: IUCN criteria for protection (Balgos, 2001).

main criteria	Scientific importance	National or International importance	Biogeographic criterion	Possibility	practicality	Ecological criterion	Social importance	Economic importance

Zoning of the study area was carried out based on IUCN criteria for protection. The method has been developed as a spatial decision support tool for land use planning. To implement this method the following steps were done:

A) Identification and definition of protection zone for the Parishan Lake.

B) Identification and preparation of information layers related to the protection zones.

C) Adaptation of the field observations with the data layers.

D) Determination of the numerical model for digitized sub-criteria map-layers.

E) Overlaying the data layers for each of the zones.

F) Editing the final map based on the principles of sustainable use.

G) Final zoning of Parishan Lake with protection use.

It should be noted that the steps (f) and (g) does not belong to the MCE Method and they can be related to the sustainable use of Parishan Lake. Although the biological criteria have been considered from beginning, to obtain the final result it is necessary to compare the data layers with international principles. In study ahead, the areas that have a high sensitivity against tourists' visit or enjoy considerable significance in terms of ecological and biological aspects were introduced as protection zone. During this study, map layers were digitally prepared in the environment of Arc GIS 9.3 Software on the scale of 1:25000. Based on the presented numerical model, the wetland zones are comprised of fifteen data layers as follows:

1- residential areas, 2- religious places, 3- soil types, 4- land capability, 5- land use, 6- the land cover of the of flooding-lake habitats, 7- physiographic distribution of land cover, 8- land cover characteristics (density), 9- land cover characteristics (stability), 10- recreational facilities, 11- the hydrographic of the lake bed, 12- lake bed gradient, 13- communication paths and 14- aquatics dispersion.

Weighted Linear Combination (WLC) Method was used to integrate data layers and determine the appropriate zone for each region (Eq.1).

$$S= \Sigma_{i=1 \text{ to } n} W_i X_i * Д\ C_i \quad (1)$$

Where,

S= the suitability of the study area for the considered zone, W_i= the weight of each layer, X_i= the fuzzy layer called factor, Д=multiply mark, C_i= Boolean layer which is called constraint [13,14,15,16]. The fuzzy layer is the layer that holds its value in the range between zero and one. Meanwhile, the constraints include the layers that indicate unsuitability of the area for the intended land use (in the research criteria like distance to road buffer, prohibiting construction in the watershed areas and distance to sensitive habitats were considered as the study constraints). The constraint layer just takes two values; zero and one. It was defined so that the suitable areas take zero and vice versa. The considered numerical model presented for the optimal weighting of the wetland zoning criteria is presented in Tables 3 and 4. As it is obvious from the numerical model, all the mentioned layers are not used in all models.

Table 3: Soil type and weighting values.

Numerical value	Soil Material (T2)	Numerical value	Soil type (T1)
1	Suitable for agriculture and Irrigation	1	Floodgate
2	Partly suitable for agriculture	1	Rocky and mountainous
3	Unsuitable for agricultural	1	Low permeability and floodgate
		2	Steep and erosion prone
		2	Steep and rocky
		2	Steep
		2	Steep, rocky and erosion prone
		3	Low permeability and rubble
		3	Gravel and rubble
		3	Salinity limit

Table 4: Vegetation type and weighting values.

Numerical value	Coating type (T3)	Numerical value	Durable coating (T4)
1	aquatic zone	1	Muddy
2	Tall stand	2	Less durable
3	No vegetation	3	More durable

As it is shown in Table 2, soil type 1 with a coefficient range of 1 to 3 is classified into 10 classes while soil type 2 with a coefficient range of 1-3 is categorized into 3 classes.

As regards there was poor information about the aquatic environment, MedWet Method was applied to prepare the map layers including habitat classification, physiographic distribution of the land cover, land cover characteristics (strength and density) and the land cover of flooding-lake habitats [27,28,29]. MedWet method is a method specific to classification of wetland habitats [18,19]. By applying the parameters such as hydrology, soil and land cover, it assigns boundaries identifies and assign the boundaries of the wetlands. As demonstrated in Figure 2, the MedWet has a stepped structure and consists of system, sub-system, and in lower levels; class, sub-class, dominant species as well as the parameters determining water level and salinity. The method has an 8 to 10 digit code to identify a habitat. Then, by means of MedWet System and data adaptation in GIS, the digital maps of these layers were obtained. Finally, the wetland zoning map was prepared by applying the data related to the functions, sensitivities, threats and the requirements for protection of the lake habitats and overlaying them with the habitat maps and the other layers.

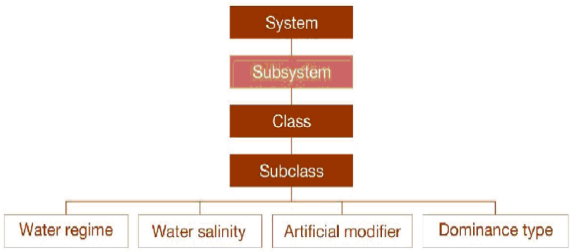

Fig. 2: The structure of MedWet system [26].

Results and Discussion

The zoning results of Parishan Wetland performed by means of MCE and numerical models are offered in the followings. The final output was presented as a 1:25000 scale map. It is worth noting that generation, conclusion and integration of information were the most important phase of the research ahead.

The results obtained from slope map showed that about 91% out of the whole lake area has a slope ranging from 0-1% while 6% of total area has a slope between1-2%. In the meanwhile, slopes ranging from 3-2% cover only 2% of the lake entire area. Finally, less than 1% of the lake area in the northeastern part has a slope between 3-4%. The results indicated that a large part of the lake area has a slope range of 0-1% (Figure 3).

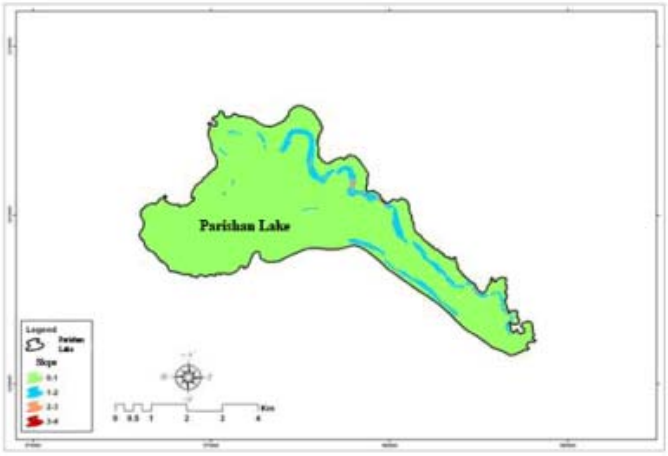

Fig. 3: The slope of the Parishan Lake bed.

Based on the aspect map, a large part of the lake (around 58% of total area) has a northward direction. The east direction allocates itself the second vast aspect in the region (26% of whole). West (6%) and south (10%) directions which have overlap with each other include most of the western, northern and eastern parts of the lake. These results show that the north direction is dominant in Parishan Lake (Figure 4).

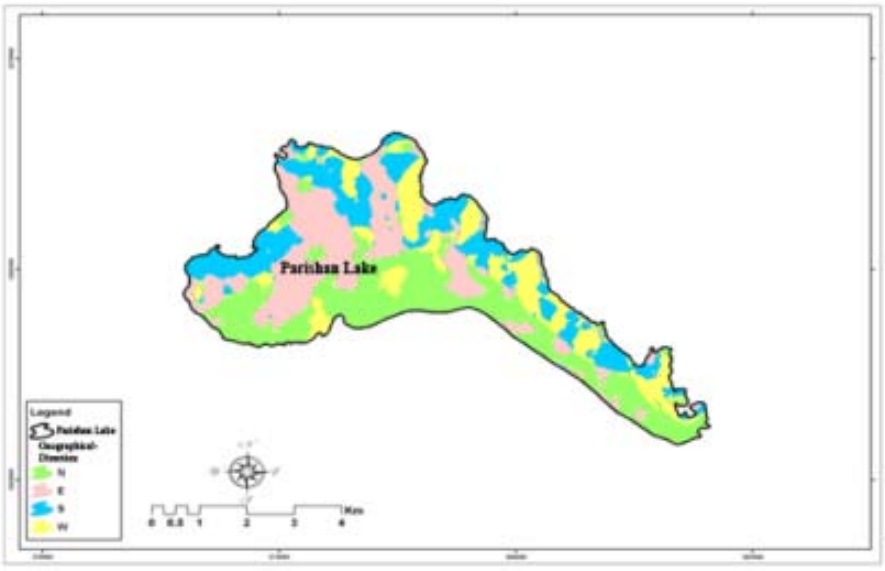

Fig. 4: Geographical aspects of Parishan lake bed.

Based on the hydrographic map of the lake, the north-central parts of the lake often have a height of 816 m above sea level. The maximum height of the lake is about 819 m above sea level. This represents an average depth of 3 m for Parishan Lake (Figure 5).

Fig. 5: Hydrograph of Parishan lake bed.

Each of the three parameters of slope, geographical aspect and hydrographic status of the lake bed were investigated and then the relevant maps were prepared. Finally, by overlaying the map layers, Digital Elevation Model (DEM) of lake bed was prepared in Arc GIS Software. Knowing the DEM of the lake bed, can be determined soil quality, herbage and capability of each land unit.

Sensitivity Of Parishan Lake Habitats:

As is shown in figure 6, possible activities in high sensitive habitats (illustrated in pink) are just limited to research and monitoring with the permission of EPA. Activities such as licensed fishing, photography, ecotourism and reed cutting are allowed in moderate sensitive habitat demonstrated in blue. In the habitats with low sensitivity depicted with yellow, in addition to mentioned activities, grazing, boating and fishing with hook as well as tourism with low impacts are authorized. In Figure 6, green strip indicates buffer zone where in addition to the noted above activities, cycling, horse riding, walking, outdoor recreation, and agriculture with little effects are permitted.

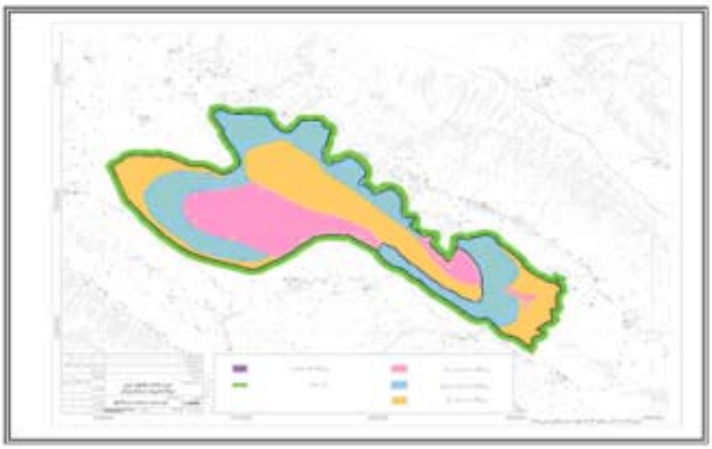

Fig. 6: Sensitivity of Parishan lake habitats (PWMP, 2009) .

Figure 7 demonstrates final zoning map of Parishan Wetland.

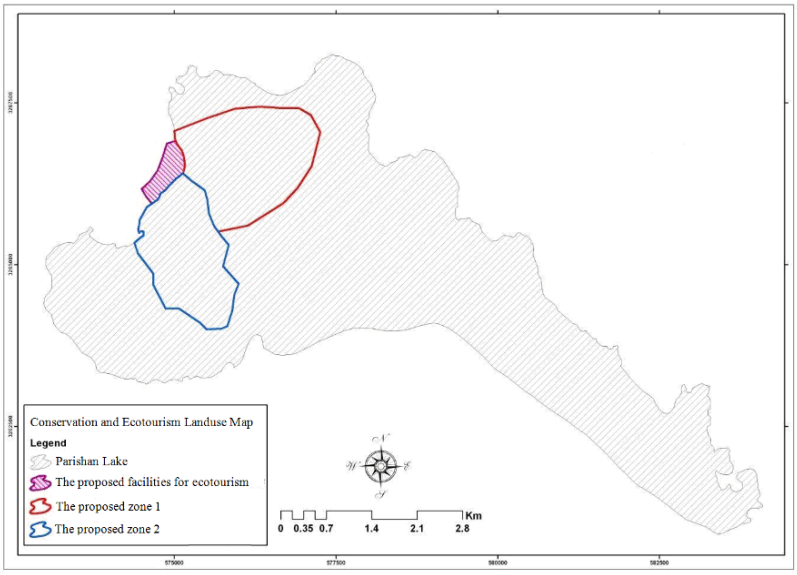

Fig. 7: Map of wetland conservation zones.

Conclusion:

Regarding management objectives of each protected area; zoning will be carried out to achieve predefined goals. In Multiple Criteria Evaluation (MCE), different criteria are used to achieve research particular purpose. The satisfaction index of land is obtained in this way. Accordingly, after integration and synthesis operations, suitable zones for nature protection were determined in Parishan Lake. The research findings are here discussed briefly. In this study, the main purpose of Parishan lake zoning has been biodiversity conservation with the lowest conflict to environment and ecosystems in the vicinity of the lake as well as the birds, amphibians and fish. Regarding the style sheet of management plan of protected areas, if a land has more than one conditions of protection is considered a Conservation Zone that represents the most important and vulnerable of natural values. Thus, all kinds of human activities that lead to change the value of this zone are prohibited. Accordingly, only activities that are necessary for managing and protecting the quality of these zones are permitted. These activities mainly include a simple environmental monitoring and the least research facilities imposed minimum impact on the zone. In this zone introducing non-native species are not allowed. According to FAO classification (1988), conservation zone can be classified into two classes: Strict Nature Reserve Zone and Primitive Zone. Considering that Parishan Lake is a part of Arzhan and Parishan Biosphere Reserve and as well as is one of Ramsar International Wetlands, hence, conservation zone enjoys great importance in this area which has been obtained by overlaying the map layers in the environment of GIS Software. This map uses Multi Attribute Decision Making (MADM) Approach to investigate the current suitability of the land for nature conservation. As is shown in Figure 7, the zoning results are specified through three main zones. Besides, the obtained results indicated that 7% of whole study area has suitability to establish intensive recreation use. Therefore, it was called Intensive Recreation Zone where is considered visitors' center. About 31% of the wetland area is suitable for extensive recreational use, so it was named as Extensive Recreation Zone wherein development is possible conditionally with respect to ecological aspects. This zone was divided into two zones; zone 1 and zone 2. Zone 1 is steeper than 2 and is located on northern accessibility of the lake. Considering that zone 2 is surrounded by southern and western parts of the lake that is the main laying and rest place of the birds, thus, recreational activities must be done with more carefulness and circumspection, under supervision of environment peacekeepers and environmental experts. The remaining 62% consisted a major part of the lake, has been assigned to nature conservation wherein tourism development is prohibited under all circumstances. Field studies conducted in Parishan wetland confirm the accuracy of the analyses obtained from MCE, ArcGIS and MedWet. So that, a part of aquatic and wading birds habitats that is situated within sensitive ecotone area of Parishan Lake, eastern and northern edge canebrakes is also belonged to the conservation zone. Regarding the wetland importance and its ecological, conservational and recreational importance values, by providing some strategies can be prevented the wetland further degradations. Some of the best possible strategies are pointed in the followings:

1. Determining a clear priority for protection of the wetland based on the international standards

contained in Ramsar Convention and improving the quality and quantity of the wetland resources through a written management plan with cooperation all beneficiaries and stakeholders.
2. In managing the wetlands conservation, a high priority should be allocated to promoting public awareness in relation to wetland values and dangers threatening the lake.
3. Strengthening sentry cadre in terms of education, personnel and equipment.
4. As regards, agricultural lands and habitats important to birds are all located on the eastern and southern parts of the lake, it is necessary to determine the wetland buffers as soon as possible. Thereby, the land uses within the wetland buffer must be changed to nature conservation.
5. The survival of the lake depends on water quality and how to access it, so improvement of water source management as well as care in use of agricultural chemicals and sewage flows are the most important requirements to protect the values of the lake.
6. Durability and sustainability of the wetlands is depended on cooperation of local communities in its management. Therefore, these communities should be involved in the management and conservation of the wetland. The indiscriminate exploitation of the wetland resources should be avoided.
7. Periodic monitoring of bird count and land cover as well as assessing the changes in fauna and flora.
8. Controlling illegal fishing in the spawning season, determining the fishing seasons as well as issuing fishing license based on production capacity of the lake.
9. Investigating ecological needs and implementing support programs for sustainability of population of endangered animals including water dog.
10. controlling the indiscriminate harvesting of straw and finding a solution for development of straw bed.
11. Performing waste collection programs in the villages around the wetland recreational zones.
12. Preventing inappropriate land use changes in lands surrounding the lake through environmental impacts assessment studies.
13. Planning separately in each zone of Parishan Wetland.
14. Organizing a joint committee to coordinate the programs and measures of different institutions and relevant groups for wetland management as well as supervising and monitoring activities.

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