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Effects of the Caspian Sea water level change on Boujagh National Park, southwest the Caspian Sea

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ABSTRACT

Nowadays, climate change and sea level rise are serious threats to the social, economical and environmental vulnerability of the ocean coasts all around the world, and the Caspian Sea rapid fluctuations during the third millennium have set different conditions on the environmental structure of coastal areas. The main target of this study is to evaluate the coastline morphology behavior and the deformation of habitats and ecological condition of Boujagh National Park (BNP) due to Caspian Sea level changing during the progression and regression phases between 1978-2019. Initially, based on the available scientific documents, familiarity with the study area was carried out and the axes of measurements were defined. In field operations, sedimentation and erosion units of coastal zones and also different habitats were identified and geographically determined. In the next step, the rate of deformation of coastal habitats was calculated and classified using satellite images and GIS, and ultimately, validity of the results was verified with field evidence. The comparison of regression amount in BNP indicated that maximum negative shoreline displacement (892 m) has occurred in the east part of Sefid-rud River mouth during 1978-1995. So that, the shoreline negative changing has reached to 850 m in the north- western of central part of study area, while 738 m in north- eastern of central part in the period of 1995- 2019. The inundation zone extent has declined 104 ha between 1995 and 2019. Also the sea regression amount of area was 111 ha in the period of 1978- 1995, while changed to 380 ha during 1995-2019. During the last 24 years, there have been widespread environmental alterations in the studied area and a large part of the coastal wetlands has been dried up. The most important habitats affected by the Caspian Sea fluctuations include coastal lagoons, dry and wet sandy beach, fluvial meadow and river estuary.

Keywords: Caspian Sea, Environment, Sefidroud, Boujagh, habitats, morphology.

INTRODUCTION

In the age of Antherapocene (1945-2019), human beings made great changes on the planet (Ranjan *et al*. 2006). Technology development and economy growth in many countries have caused excessive greenhouse gas emissions in the Earth's atmosphere, and global warming is one of the major concerns of the world (Saunders *et al.* 2013). Nowadays, melting of polar ice and increasing the ocean water levels is one of the serious environmental problems of our planet (Davidson *et al*. 2018). The ocean water levels increased by about 30 cm during the twentieth century, and it is estimated that by the end of the 21st century, the level of seawater levels would increase approximately 2 m (Slangen *et al*. 2012). At present, rising levels of seas have caused floods, coastal erosion, and the destruction of freshwater lagoons (Ramsar Convention 2018). The dynamics of the oscillatory behavior of the Caspian Sea varies with the oceans (Khoshravan & Vafai 2016). The Caspian Sea level has fallen over 150 cm

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since 1995, and the fluctuation rate of the sea was over 100 times more than the rate of annual fluctuations of the ocean (Khoshravan & Vafai 2016). Due to the decreased Caspian Sea level, the extent of the dry sandy beaches has been raised, while the area of coastal wetlands has been greatly reduced (Khoshravan & Vafai 2016). Therefore, fluctuations in the Caspian Sea level will cause alterations in the morphological profile of the beaches and also in the structure of the ecological units. The Boujagh National Park (BNP) environmental consequences associated with the Caspian Sea fluctuation is the main aim of this study, during 1978 - 2019, when its level has been altered. So far, several studies have been conducted on the fluctuations of the Caspian Sea level, and also on the morphological and geological aspects of Sefidrud Delta by various scientists (Kosarev & Kostianoy 2005; Kroonenberg *et al*. 2000; Kazanci *et al*. 2004; Khoshraftar 2005). The results of the previous studies indicate that the shoreline displacement rate in the studied area was influenced by fluctuations of the Caspian Sea and the Sefidrud discharge in western, central and eastern regions (Alemi Safaval *et al*. 2018). It was also found that the severity of the erosion vulnerability of the coast in the central Guilan region is very high due to the hydrodynamic forces (Khoshravan 2007). The long-shore currents and sediment volumes in Sefidrud River, discharging to the Caspian Sea have played an important role in the formation of sandy spit and the establishment of coastal wetlands in the studied area (Naderi Beni *et al.* 2013). The growth of sand spit in the coastal zone of the northern part of BNP has led to recreation and development of the Kiashahr and Zibakenar coastal wetlands (Kousari 1986). At the same time, decreasing in the Caspian Sea water level, the formation of sandy spit and the separation of Kiashahr and Zibakenar wetlands from the sea coasts are the most important morphological events in BNP (Haghani & Leroy 2016). However, so far there has been no research concerning to the effects of fluctuations in the sea level on the BNP environment. Therefore, in this study, the assessment of coastal deformation and the response of coastal habitats located in BNP are considered as the main objective under the influence of the Caspian Sea level fluctuations. The management of conservation of the environmentally sensitive nature of the BNP is impossible without consideration of the impact of fluctuations in the Caspian Sea level on ecological and environmental units.

MATERIALS AND METHODS

Boujagh National Park (BNP) is located in Guilan Province beside Astaneh-Ashrafieh and Kiashahr cities. This area is located at longitude (49°, 52', 03") and (50°, 52', 11") and also latitude (37°, 25', 47") and (37°, 28', 19") coordinates of the north (Fig. 1). BNP is the first national land-sea park in the north of Iran, and covers Kiashahr and Zibakenar wetlands, delta and estuary of Sefidrud River. The latter is the largest river in the country with an area of 61600 km^3. The water conditions of this river in the vicinity of the Caspian Sea have led to the formation of a large delta, with 2400 km^2 in size, including BNP and its coastal wetlands. The average width of the river close to the estuary and also its bed slope in 5 km far from the coastline are about 1.5 km and 0.09-0.07% respectively. Therefore, the canal and marginal land of this river is very vulnerable to alterations in the sea level (Kazanci & Golbabazadeh 2013). The average annual sediment load of the river is about 5 million tons, and its delta was formed 3500 years ago (Kazanci & Golbabazadeh 2013). The sediments of the study area include: river alluvial deposits, flood plain, wetland, coastal and offshore sediments (Kazanci & Golbabazadeh 2013). Based on the meteorology of Iran, the climate of this region is affected by the oceans and Mediterranean climate and has a wet climate (Ghahreman *et al.* 2004). The average annual temperature and precipitation are 17 °C 1356 mm respectively. The average warmest and coldest temperatures in summer and also in February and March are 33°C and 0.4 °C respectively (Ghahreman *et al.* 2004).

The natural and environmental geographic situations of the studied area were assessed through the study of available scientific documents (research papers, specialized reports, thematic maps). The coastal morphological characteristics were investigated dividing the BNP by two eastern and western regions around the two sides of Sefidrud River. Samplings from dominant plant species and soil cover were carried out along 8 transects and 32 stations (Table 1 and Fig. 1) followed by collecting, drying and transferring the species to the laboratory, and identifying them using floristic atlases of Iran (Rechinger 1963-1998), Turkey (Devis 1965-1988), the former Soviet Union (Komarev 1934-1954) and Europe (Tutin *et al*. 1964-1980). Thereafter, habitats located in the coastal area of BNP were identified followed by evaluating coastline changes and habitat deformation, using remote sensing technique and interpretation of satellite images. So that, Land-sat satellite images, ETM and LOI sensors for 1995 and 2019 were pre-processed, optimized and processed using the tools available in Envi 5.3 software, and finally, using the Support Vector Machine (SVM) method, afterward, landforms and coastal habitats

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(river, sandy beach, lagoon, sea, fluvial meadow and vegetation) were identified and classified on the images. So the trend of the coastal habitat transformations was calculated using change detection workflow tools in Envi 5.3 software (Rojas *et al*. 2013). Moreover, by transmitting all data to Arc-map 10.5 software, the habitat area alterations were calculated. Subsequently, the area of wetlands in multi-temporal images was determined by calculating the NDWI index followed by determining Caspian Sea coastlines by analyzing the ratio between the green band to nearest infrared one (b2 / b4 > 1) (Alesheikh & Nouri 2007), and finally by transferring collected data to the GIS environment in Arc-Map 10.3 software and drawing the coastline displacement maps as well as the map of habitat deformations.

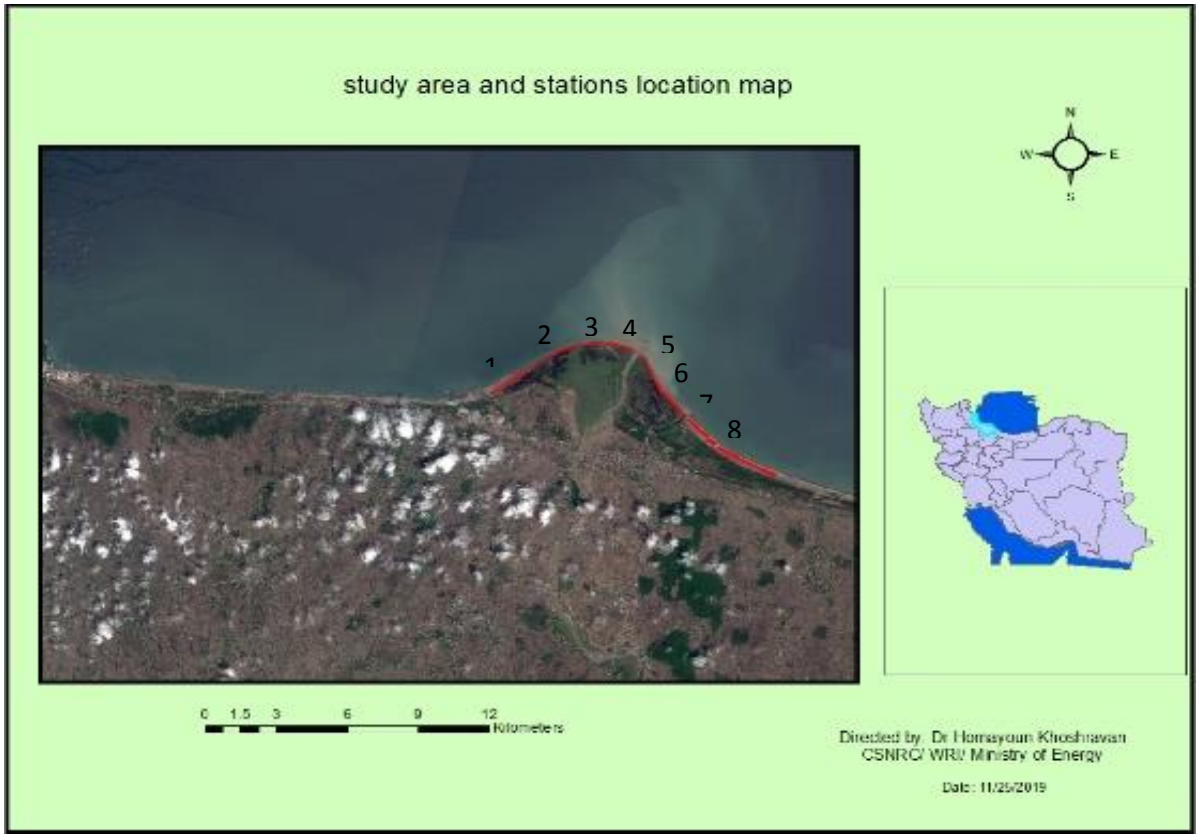

Fig. 1. Study area and transects location map.

Table1. Geographic position of all Transects in the study area.

Transects Number	Geographic position UTM Coordination System (Zone 39)	
	X	Y
1	400187.00 E	4145717.00 N
2	402251.00 E	4146956.00 N
3	404067.00 E	4147749.00 N
4	406139.00 E	4147487.00 N
5	406914.00 E	4146701.00 N
6	407982.00 E	4145134.00 N
7	408755.00 E	4144130.00 N
8	409630.00 E	4143254.00 N

RESULTS

Evaluation of coastal morphology characteristics

The results of remote sensing studies showed that the beaches of BNP in terms of coastal morphology, consist of three sections including the sedimentation, transition and erosion zones (Fig. 1). Eroded coasts are located in the

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central northern part of the BNP adjacent to the western and eastern shores of the Sefidrud River (transects 4 and 5). Coastal areas with active sedimentation are developed in northeastern areas (transect 6), (adjacent to the northern part of the Kiashahr wetland) and northwest (transect 3), (adjacent to the end northwestern of the Zibakenar wetland), and transition beaches (containing both characteristics of eroded coasts and active sedimentation), are located in the distance between the active sedimentation zones and the eroded ones. The most important coastal landforms are: sand spit and eroded terraces (Fig. 2). The BNP beaches are divided into three areas in terms of geometric structure: 1- the very low-steepness coastal areas with prominent embankment in the eastern and western parts (adjacent to the Sefidrud River delta), 2- a low-slope beach with a broad embankment in the western and eastern ends, and 3- intermediate coastal area.

Fig. 2. Prevailing landforms in the study area: (Left: sand spit along the Sefidrud River delta, Right: the eroded terraces close to the western coast of Sefidrud River).

Identification of coastal habitats

Totally, based on morphological characteristics, dominant plant species and the physical and chemical characteristics of soil cover, six coastal habitats were identified in the study area:

The dry sandy beach habitat is located at the margin of the shoreline of the Caspian Sea and in the beach area. Soil contains dry sand. Pesamophytic plants are the most important group of this habitat. The most important plant species identified in this habitat include: *Argusia sibirica*, *salsola kali*, *Senecio vernalis*, *Convolvulus persicus*, *Cakile maritime*. The presence of the dominant native species in this habitat has an important role in the formation of small rippling and early sandy hills or the nabkha, in addition to the stabilization of sandy sediments. Due to difficult ecological conditions, the abundance of different plant species is low. This section is a good place for the Caspian mammal such as seals to rest and there are also birds near the shore (Fig. 3).

Fig. 3. Sandy beach and fluvial meadow habitats. Left: sandy beach with (*Senecio vernalis*) and right: fluvial meadow with dispersed *Juncus acutus* and dominated grasses.

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Wet sandy beach habitat develops on the northern part of BNP along the coastline of the Caspian Sea in the back area of the coastal embankment at the site of the troughs. *Juncus acutus* is the predominant biomarker for identifying this habitat on the margin of wet sandy part of Boujagh and Kiashahr wetlands and also the northern part of BNP. The most important plant species in this habitat are: *Aster tripolium, Rubus sanctus, Carex otrubae, Juncus maritimus, Trifolium* sp. (Fig. 4). This habitat is a good place to live for aquatic birds like *Drogheda*. This biological unit is considered as an intermediate region of wetland and dry land.

Fig. 4. The lagoon, marginal lagoon and brackish marsh habitats in BNP with the plant species: *Phragmites australis, Schoenplectus litoralis, Juncus acutus*.

The fluvial meadow and grassland habitat cover a large part of BNP and include alluvial deposits of Sefidrud River covered by grass and meadows. This habitat is a good place for growing rare plants and bird gathering. Wide meadows in this habitat are a good pasture for livestock and there are sparse species of *J. acutus*. The cover of this habitat is sandy and in the rainy months of the year, it turns to a freshwater lagoon (Fig. 3).
Marginal wetland habitat is known as a place for accumulation of *Phragmites* and *Typha*. This habitat is located between the dry land and the wetland, such that the green belt of *J. acutus* covers its margin. It has a large population of aquatic birds. This habitat is well developed in the northern region of the Boujagh Wetland. Plants including *Phragmites australis* and *Schoenplectus litoralis* are some predominant species of this habitat (Fig. 4).
Wetland or lagoon habitat is a gathering place for migratory birds in winter, including abundant fish. Boujagh and Zibakenar wetlands in the west of the mouth of the Sefidroud River and Kiashahr in the east are the most important wetland habitats in the study area. Soil texture in this habitat contains a fine-grained silt and clay. The most important plant species in this habitat are *P. australis*, *S. lacustris*, *T. latifa* and *Alnus glutinosa*. On the margin of the shoreline of the Caspian Sea, in the western part of Kiashahr Wetland, saline water penetration has caused complete alteration in the vegetation. So that, only *Ruppia europea* and the green algae expand there.
The habitat of Sefidrud estuary is the intersection of Caspian Sea brackish water and the river fresh water. It has sandy cover and clay suspended matter, and also *J. acutus* is abundant on its coastal margin. However, in the central area and on the sand spit, the central part of the spit is free of vegetation.

The rate of shoreline displacement and alterations in coastal zone area

Analysis of regression in BNP indicated that maximum negative shoreline displacement (892 m) has occurred in the east part of the Sefidrud River mouth (RME) during 1978- 1995, while the shoreline negative alteration has reached to 850 m in the north-western of central part of the study area (NWC) and 739 m in north-eastern of central part during the period of 1995-2019 (Table 2). The maximum positive shoreline displacement was about 791 m in the north western (NW), 724 m in the eastern part of the Sefidrud Delta (RME), and 738 m in the northeastern parts (NE) during 1978-1995 (Table 2). The minimum progression has occurred in the northeastern (NE), eastern (NEE) and western (NWW) parts (Table 2). So the coastal regions with high vulnerability to the Caspian Sea fluctuation are located innorthwestern of central (NWC) and northeastern of central (NEC) parts. Moreover, the beach zone of the Sefidrud Delta has the maximum alteration threshold in the fluctuation periods of the sea. The inundation zone was 508 ha during 1978-1995, while its extent has declined to 104 ha between 1995-2019. In addition, the sea regression amount was 111 ha in the period of 1978-1995, while changed to 380

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ha during 1995-2019. So the progression and regression phases of the Caspian Sea have caused different morphological response along the coastal zone of the study area.

Table 2. The shoreline alterations, recreations and erosions in the study area during 1978-1995 and 1995-2019.

No.	Coastal Zone	1978-1995		1995-2019	
		regress (m)	Progress (m)	regress (m)	Progress (m)
1	NWW	160	74	394	0
2	NWC	0	289	850	0
3	NW	305	791	0	0
4	RMW	276	486	0	438
5	RME	892	724	0	420
6	NE	0	738	401	0
7	NEC	0	0	739	0
8	NEE	130	0	285	0

The highest shoreline advance has occurred in the NE, RME, NW, RMW and NWC, while other parts had very low positive change during the progression period of the Caspian Sea (1978-1995). The maximum regression of shoreline was determined in RME, whereas other transects exhibited low grade of negative shoreline alterations in the above-mentioned period (Fig. 5).

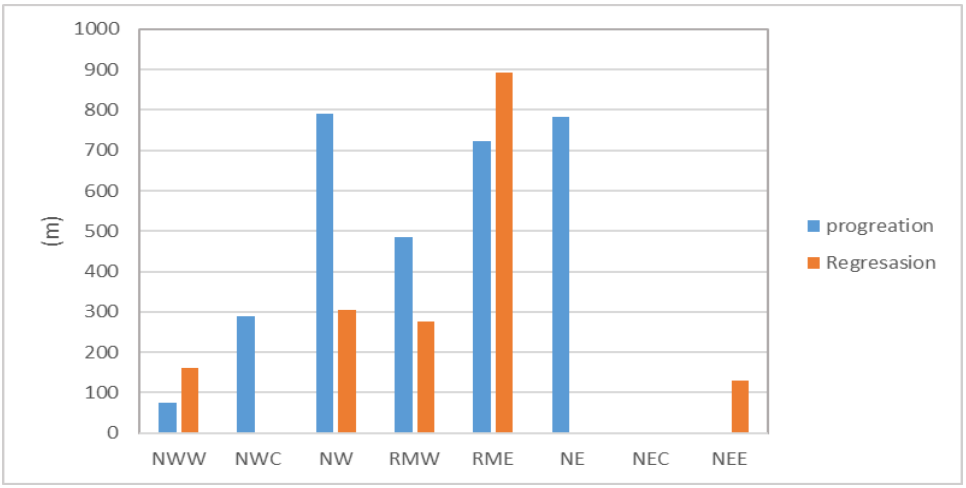

Fig. 5. The shoreline displacement rate comparing during the progression phase of the Caspian Sea (1978-1995).

The shoreline alteration in the regression phase of the Caspian Sea was great in NWC, NEC, and NWW, NE, NEE, while the other parts revealed no negative shoreline displacement during 1995-2019 (Fig. 6). The positive shoreline displacement has occurred only around the Sefidrud Delta (RME and RMW) during the same time (Fig. 6).

The process of alterations of habitats and ecological units

The study area is covered by several habitats such as sandy beach, Sea, River, fluvial meadow, vegetation and coastal lagoons (Fig. 7). Fluctuation phase of the Caspian Sea has affected different habitats and the remote sensing analysis shows that the area of several habitats have been changed during progression (1978-1995) and regression phases (1995- 2019).

Beach zone areas were 536, 227 and 578 ha in 1978, 1995 and 2019, while those of the coastal lagoon were 192, 363 and 158 ha in 1978, 1995 and 2019 respectively (Table 3). Fluvial meadow areas were 398, 368 and 205 ha in 1978, 1995 and 2019, while the vegetation areas were 908, 898 and 1479 ha in 1978, 1995 and 2019. In the case of river habitat, the areas were 82, 82 and 267 ha in 1978, 1995 and 2019 and those of the shore zone, were 1919, 1898 and 1348 ha in 1978, 1995 and 2019 respectively (Table 3). The area of sandy beach decreased by

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309 ha during 1978-1995, while increased by 351 ha during 1995-2019 (Table 3). The alteration speed of sandy beach ratio in 1995- 2019 was about 0.8. The area of coastal lagoons increased by 171 ha during 1978-1995, whereas decreased by 205 ha in the period of 1995-2019. The speed of coastal lagoon habitat alteration during fluctuation phase was about 0.9. Fluvial meadow habitat decreased by 30 ha during 1978-1995 while by 163 ha between 1995 and 2019. The velocity of fluvial meadow habitat alteration during regression phase was 3.9 times faster than the progression phase. Vegetation habitat declined by 10 ha during 1978-1995, while decreased predominately by 581 ha during 1995-2019. The speed of alteration in vegetation during the regression phase was 41.7 times faster than progression phase. The river habitat area increased by 199 ha during 1978-1995, while declined by 14 ha between 1995-2019. So the river habitat alteration speed in regression phase was 0.11 times faster than progression phase. The area of shore zone decreased by 21 ha during 1978-1995, while by 550 ha between 1995 and 2019. The sea habitat alteration speed during the regression phase was 61.11 times faster than progression phase.

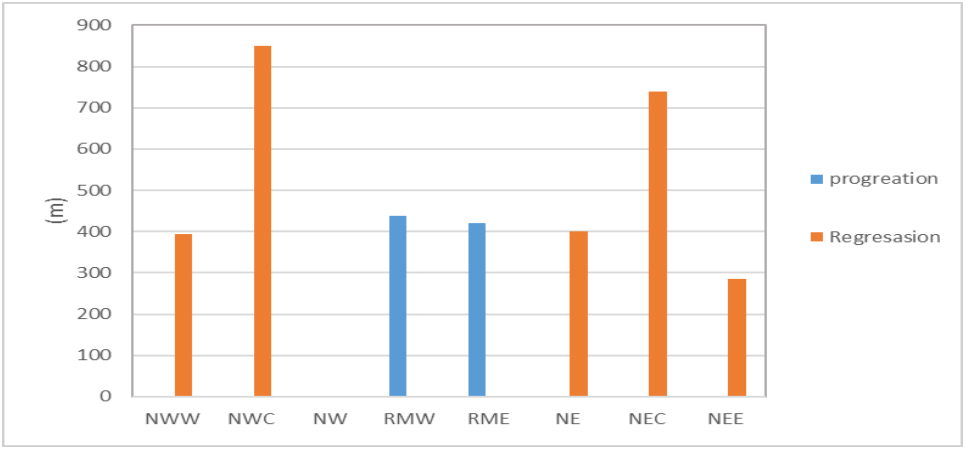

Fig. 6. The shoreline displacement rate comparing during the regression phase of the Caspian Sea (1995- 2019).

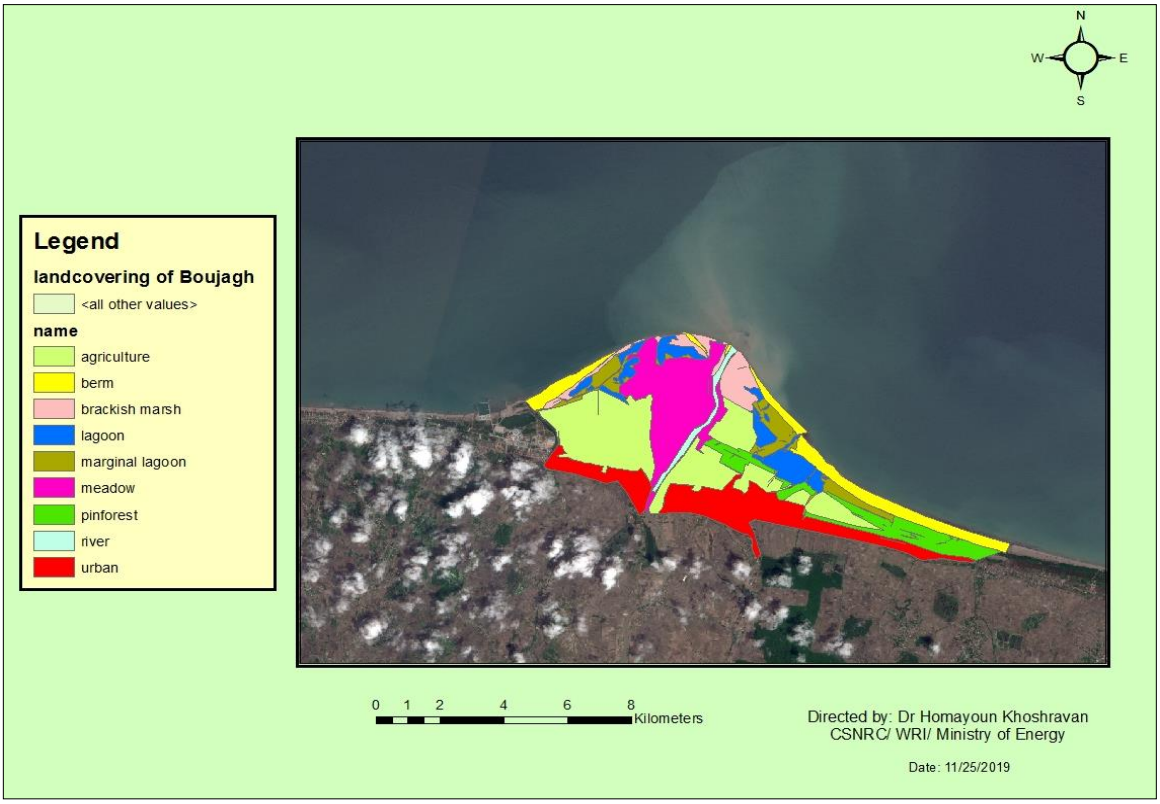

Fig. 7. The land covering and ecological unit classification map of study area in 2019.

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Table 3. Comparing the land covers and coastal habitat alterations in the study area during 1978-1995 and 1995-2019.

Habitats	1978 (ha)	1995 (ha)	2019 (ha)	Changes in the area (ha) 1978-1995	Changes in the area (ha) 1995-2019
Sandy beach	536	227	578	-309	351
Lagoon	192	363	158	171	-205
Fluvial meadow	398	368	205	-30	-163
Vegetation	908	898	1479	-10	581
River	82	281	267	199	-14
Sea	1919	1898	1348	-21	-550

The sea habitat is major ecological unit of the study area, whereas the dry land vegetation is the second important one due to its area extent (Fig. 8). The maximum habitat alteration rate of the Caspian Sea during 1978-2019 belongs to the sea and vegetation, while the sandy beach, lagoons, fluvial meadow and river take the subsequent rate order respectively (Fig. 8).

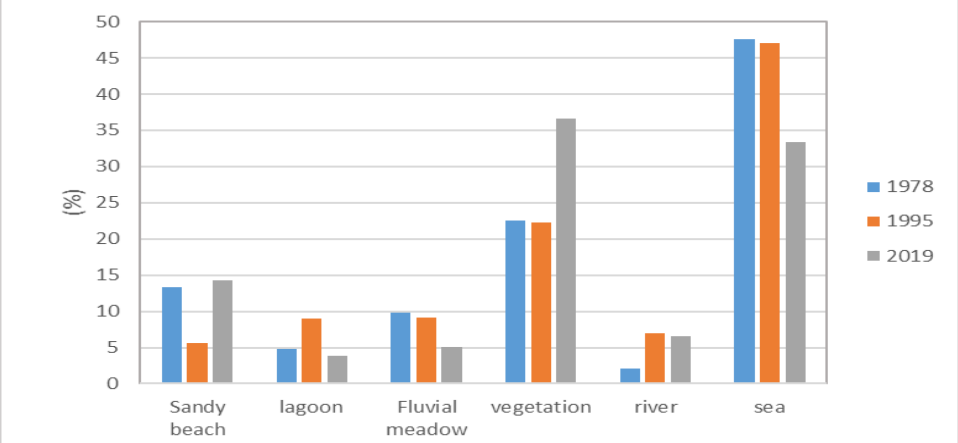

Fig. 8. Comparing the abundance rate (%) of land covers in the study area during 1978, 1995 and 2019.

DISCUSSION

Over 35% of the world's wetlands have been lost since the 1970 (Davidson *et al*. 2018). At present, the process of destruction of wetlands is widespread in nature and has left undesirable environmental effects on nature and humans. In the third millennium, attention to integrated management of wetlands and conservation of their environmental values is very important. The land and coastal wetlands surface areas are about 12.1 million km^2, slightly larger than the Greenland area in the northern hemisphere. 54% of these areas are permanent wetlands, while 46% are seasonal, covering 5.2 million km^2 of the world. 93% of wetlands are in the land ecosystem, while only 7% are located in coastal and marine areas (Davidson *et al*. 2018). The new IUCN assessment shows that 25% of the world wetland faunas are at serious risk of extinction (Davidson *et al*. 2018). Human and natural factors play a very important role in the deformation of coastal wetlands (Ranjan *et al*. 2006). Occasionally, the common effects of human and natural factors lead to adverse environmental conditions in coastal wetlands, resulting in social, economic and environmental consequences. The sea level rise of the Caspian Sea by 250 cm in the period of 1978- 1995 and its level reduction by 150 cm in the period of 1995 to date has caused the huge alterations in the coastal wetlands such as Gorgan Bay and Miankaleh Wetland (Khoshravan & Naqinejad 2018). In addition, the interruption of water exchange between the sea and coastal wetlands along with global warming has increased the drying rate of coastal wetlands (Khoshravan & Naqinejad 2018). BNP is the first Land-marine natural park and one of the 19 national parks in Iran (DOEI 1998) with a special geographical location in the vulnerable ecological zone around the southern coasts of the Caspian Sea.

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Previous studies have suggested that the Caspian Sea fluctuations during the Holocene period played a very important role in the morphological evolution the Sefidrud Delta as well as the creation of coastal wetlands in BNP (Naderi Beni *et al*. 2013). Moreover, the last complete cyclical fluctuation in the Caspian Sea from 1930 through 1995, with the difference amplitude of 300 cm was very effective in the creation and alterations of the coastal wetlands including Kiashahr, Zibakenar and Boujagh (Haghani & Leroy 2016).The coastal morphology results showed that the study area is classified to three zones (sedimentation, transition and erosion) (Fig. 1). Eroded coasts predominately develop along the mouth of Sefidrud River (RMW and RME) and active accretion zone as sand spits are developed in northeastern (NE) and northwestern parts (NW), while the transition beaches which contain both characteristics of eroded coasts and active sedimentation, are located in the distance between the active sedimentation and the eroded zones (NWC and NEC). Erosion and accretion processes were concurrently centralized along the shoreline which would be controlled by the Sefidrud River sediment discharge as well as the Caspian Sea hydrodynamic forces. The presence of sand spits and eroded terraces in the study area confirm the common confluence of river and sea. These landforms could be improved during 1995-2019. The main landform alteration along the Anthropocene time includes changing open lagoons to closed ones by sand spit development in the eastern and western sides of the study area (the Kiashahr and Boujagh lagoons). In addition, the human activity with harbor construction could lead to the sedimentation processes along the eastern part of BNP adjacent to the Kiashahr port inlet (Alemi Safaval *et al.* 2018). In addition, field monitoring clues suggest that the formation of wide sandy beach at the East and West parts of coastal zone, as well as longshore current from west to east could develop sand spits in these areas. The reduced Caspian Sea level by 150 cm during 1995-2019, has caused an alteration in the balanced level between the coastal wetlands and the shallow sea water. Moreover, the difference in the levels caused a reverse slope from the wetland towards the sea. So, at present there is a large volume of water of the coastal wetlands in the western part of Boujagh, inflowing to the sea. Concurrent with the sea level rise during 1978-1995, the rate of shoreline displacement varied along the coastal zone. The maximum negative movement of shoreline (892 m) in the east part of the Sefidrud mouth (RME) indicates that this part has low steepness and its vulnerability to the sea level alteration is very high. Also unconventional morphological behavior of NW, RME and NE parts during 1978-1995, reveals that this area has eroded by sea currents (Table 1). So the coastal regions with high vulnerability to the Caspian Sea fluctuation are located in NWC and NEC parts, and also the beach zone of the Sefidrud mouth has the maximum alteration threshold in the fluctuation periods of the sea. The difference rate of inundation in coastal zone during the Anthropocene epoch have proved that the progression and regression phases of the Caspian Sea have caused different morphological responses along the coastal zone of the study area. The highest shoreline advances have occurred in the NE, RME, NW, RMW and NWC. Moreover, the other parts exhibited very low positive alterations during the progression period of the sea (1978- 1995). The maximum regression of shoreline was determined in RME, while other transects displayed low grade of negative shoreline alteration in the above-mentioned period (Fig. 5). The shoreline alteration in the regression phase of the sea revealed great recession in NWC, NEC, NWW, NE, and NEE. The other parts of the study area exhibited no negative shoreline displacement during 1995-2019 (Fig. 6). The positive shoreline displacement has occurred only in the region close to the Sefidroud River mouth (RME and RMW) during the same time (Fig. 6). The results of land cover and habitats alterations associated with the sea fluctuation in BNP indicate the presence of active ecosystems in the dry land (sandy and wet sandy beaches and also marginal wetland) and in the aquatic environment (wetland, river and sea). By altering the Caspian Sea level since 1978, the ecological structure of each of the studied habitats has been varied in the size and displacement of ecosystems. Comparison of the annual average variation in coastal habitats indicates that the sandy beach habitat exhibited maximum alteration during 1978- 1995 followed by river, lagoons, fluvial meadow, sea and vegetation in order of priority. As the results show, the extent of the wetlands habitat territory reached about half, instead, the extent of dry ecosystems during the last regression phase of the sea between1995-2019 reached two folds (Table 2). Therefore, the reduced Caspian Sea level has changed the shape of coastal habitats, leading to the conversion of aquatic ecosystems to dry ones. If the regression process of the sea level continues in the coming years, unfortunately, the coastal wetlands of BNP will be destroyed.

CONCLUSION

The coastal areas of Boujagh National Park (BNP), along with important wetlands of international importance, have been affected by fluctuations in the Caspian Sea level during 1978-1995 and 1995-2019. These areas on both

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sides of the Sefidrud River delta have exhibited different erosion vulnerability due to hydrodynamic forces. The extent of the sedimentary zone in the eastern part (excluding Kiashahar Wetland) is much larger than the western one (excluding the Boujagh and Zibakenar wetlands). The width of sandy spit in the northwestern part of BNP decreased from west to east. In addition, the northern part displayed an active erosion regime. The reduced Caspian Sea level during 1995- 2019 led to the variation and displacement in the aquatic and terrestrial ecosystems and, in total, the habitat of coastal embankment got doubled, while the extent of coastal wetlands, got halved and eventually changed the open wetlands to the closed ones with limitation of the realm in water. By reduction in the Caspian Sea level, conditions have been provided for the domination of the dry crop habitats leading to many environmental challenges in the past aquatic ecosystems.

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نوسانات دریای خزر و تأثیر آن بر پارک ملی بوجاق

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چکیده

امروزه تغییرات اقلیمی و افزایش سطح تراز آب اقیانوس‌ها تهدیدی جدی برای معیارهای اجتماعی، اقتصادی و زیست محیطی سواحل کره زمین محسوب می‌شود و نوسانات سریع سطح تراز آب دریای خزر، طی هزاره سوم میلادی شرایط متفاوتی را بر روی ساختار زیست محیطی مناطق ساحلی پیرامونش رقم زده است. هدف اصلی این پژوهش، ارزیابی رفتار ریخت شناسی خطوط ساحلی و تغییر شکل زیستگاه‌ها و واحدهای بوم شناختی پارک ملی بوجاق متأثر از نوسانات آب دریای خزر طی سال‌های ۱۹۷۸ تا ۲۰۱۹ میلادی است. در ابتدا با مطالعه مستندات علمی موجود، آشنایی لازم با منطقه مورد مطالعه صورت گرفت و محورهای اندازه‌گیری تعریف شد. در عملیات میدانی واحدهای رسوبی و فرسایشی نواحی ساحلی و زیستگاه‌های مختلف شناسایی و تعیین موقعیت جغرافیایی شدند. در مرحله بعد با بررسی تصاویر ماهواره‌ای در محیط سامانه اطلاعات جغرافیایی، میزان تغییر شکل زیستگاه‌های ساحلی محاسبه و طبقه‌بندی شد و در نهایت، صحت سنجی روایی و اعتبار نتایج حاصله با شواهد میدانی تأیید شد. مقایسه میزان پسروی آب در منطقه پارک ملی بوجاق نشان می‌دهد که بیشترین مقدار عقب نشینی آب (۸۹۲ متر) در سال‌های ۱۹۷۸ تا ۱۹۹۵، در بخش شرقی دهانه سفیدرود بوده است و طی سال های ۱۹۹۵ تا ۲۰۱۹، جابه‌جایی خط ساحلی به میزان ۸۵۰ متر در بخش مرکزی شمال غربی منطقه مورد مطالعه و به میزان ۷۳۸ متر در بخش مرکزی شمال شرقی رخ داده است. وسعت محدوده پیشروی آب بین سال‌های ۱۹۹۵ تا ۲۰۱۹، به میزان ۱۰۴ هکتار کاهش یافته است. همچنین میزان پسروی آب دریا در منطقه در دوره ۱۹۷۸ تا ۱۹۹۵، ۱۱۱ هکتار بوده و طی سال های ۱۹۹۵ تا ۲۰۱۹ به ۳۸۰ هکتار رسیده است. در دوره زمانی ۲۴ ساله اخیر تغییرات زیست محیطی گسترده‌ای در منطقه مورد مطالعه به وقوع پیوسته است و بخش وسیعی از تالاب‌های ساحلی خشک شده‌اند. مهم‌ترین زیستگاه‌های متأثر از نوسانات دریای خزر شامل: تالاب‌ها، ماسه‌زارهای خشک و مرطوب، حاشیه تالابی و مصب رودخانه‌ای است.

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