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Applying remote sensing techniques to changes of water body and aquatic plants in Anzali International Wetland (1985–2018)

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Necessity for accurate spatial and timely information of water resources is growing up. In this study, with using Landsat images, the dynamic changes of the water body and surface vegetation and water withdrawal in the Anzali International wetland during the period 1985–2018 were evaluated. NDWI and NDVI indices were used for this purpose. The results of the area study showed that the area of the wetland increased during 1985 to 2007 and decreased during 2007 to 2018. The largest area was in 2007 (100.06 km^2). The western part of the wetland was also watered during the studied period and did not make any significant changes, and the major changes were in the eastern and central parts. According to NDVI obtained in 2018, there is less dispersal and less vegetation cover in the wetland. In general, it can be said that the dynamic of the water body and the vegetation cover of Anzali wetland is influenced by the fluctuations of the Caspian Sea surface and changes in the water body of the wetland respectively.

Keywords: water resources, dynamics, wetlands, Landsat, NDWI.

УДК 574:004.9

Изучение динамики водоёмов и водной растительности лагуны Анзали (Иран) в 1985–2018 гг. методами дистанционного зондирования

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Растёт потребность в точной пространственной и своевременной информации о водных ресурсах. В этом исследовании на основе анализа снимков с космических аппаратов серии Landsat были оценены динамические изменения водных объектов, поверхностной растительности и водозабора на водно-болотных угодьях международного значения прикаспийской лагуны Анзали на севере Ирана в период 1985–2018 гг. Для этой цели использовались спектральные индексы NDWI и NDVI. Результаты исследования территории показали, что площадь водно-болотных угодий увеличивалась с 1985 по 2007 год и уменьшалась с 2007 по 2018 год. Наибольшая площадь была в 2007 г. (100,06 км^2). Западная часть водно-болотных угодий также подвергалась поливу в течение исследуемого периода и не претерпела каких-либо существенных изменений, при этом основные изменения произошли в восточной и центральной частях. По данным NDVI, в 2018 г., на заболоченных территориях наблюдалась наименьшая плотность и площадь растительного покрова. В целом можно сказать, что главным фактором, влияющим на динамику водоёмов и растительного покрова водно-болотных угодий Анзали, являются колебания уровня поверхности Каспийского моря.

Ключевые слова: водные ресурсы, динамика, водно-болотные угодья, Landsat, NDWI.

Wetlands make ecosystems that are essential for maintaining the quality of the environment, the habitat of fish and wildlife species, and other human needs [1]. On the other hand, due to various natural and human impacts, wetlands face serious pressures such as: sea levels elevating, climate changes, increased demand for natural resources and cumulative environmental stressors [2]. Though, under the influence of natural and artificial interactions, numerous wetlands have turned into agricultural land or urban land, and these fundamental changes in the characteristics of the wetland have attracted widespread attention from the researchers [3, 4]. Long-term monitoring on aqueous dynamics is essential to improve the understanding of the health and performance of wetland ecosystems [5]. The efficiency, precision and strength of monitoring tools for wetlands in large areas, following their degradation and destruction is essential, in spite of many advantages and functions they provide for humans [6]. Precise mapping of the wetland is a significant instrument for comprehension wetland performance and monitoring their reflection to natural and human activities [7].

Wetlands have dynamic hydrological characteristics that are found in abundant complex lands, and it is often difficult to monitor *in situ*. Earth monitoring (EO) and geographic information systems (GIS) are an effective tool for not only collecting, storing, managing and retrieving a lot of spatial and non-spatial data, but also for spatial analysis and integration of these data for effectively output evaluation, and modeling [8, 9], supporting efficient management of wetlands and helping to improve functioning of the conservation [9, 10].

It is identified that there are 94 important international wetlands in Iran among which 35 wetlands have been registered in the Ramsar Convention in 24 sites. All of these wetlands have suffered heavy losses in recent years. Activities such as inappropriate water supply policies, the implementation of oil projects, dam construction projects, development of roads, the management of wastewater and industrial and municipal waste to wetlands, and the introduction of non-native species faces relatively all of Iran's international wetlands to death. Gavkhooni lagoon, Lake Urmia, Meighan, Bakhtegan, Anzali and many other such wetlands endangered serious threats [11, 12].

The Anzali wetland was registered in the International Convention on Wetlands in Ramsar in 1975 and the International organization of Bird Life also recognized this wetland as an "Important Bird Area" [13]. Nowadays not scientifically short-term plans such as introduction of non-native species, disturbing the balance of inland and outburst of wetlands, construction of roads and bypasses, drainage and change of land use, unlawful land occupation, Anzali wetland changed to the index of declining wetlands in the northern coastal area of Iran. The Anzali Wetland is now listed on the Montreux Record, and according to that country, Iran is forced to rebuild the site and prevent its ecological changes [14]. Overally, considering that the Anzali International Wetland is one of the most important wetlands in Iran and water volume declining induced a lot of environmentally problems in the catchment area, especially its aquatic species; therefore, the importance of monitoring this wetland is more than ever. So, the purpose of this study is to investigate the dynamics, vegetation surface and water withdrawal of Anzali International Wetland using Landsat images in period of 1985–2018.

Materials and method

Case study. The Anzali wetland is located on the southwestern coast of the Caspian Sea, in Gilan province situated at north part of Iran, near Bandar-e-Anzali city, in the 37º4' N, 49º22' E. The position of the wetland is visible in Figure 1 (see color tab).

The climate in the northern part of Iran, where the Anzali wetland is located, is known as the hyrcanian or Caspian climate [15]. The Anzali wetland is 24 meters below the free water level. Anzali wetland is a suitable habitat for spawning and nursery of fish, as well as place for breeding, spawning, and hibernation of many species of waterfowl.

Anzali wetland is separated by a sandy border about 1 kilometer from the Caspian Sea (except in one area). The main vegetation is the *Phragmites australis*, which sometimes reaches a height of 6 meters. *Azolla filiculoides* in 1984 were introduced by the Iranian Scientific and Industrial Research Organization for the purpose of forage production for livestock and poultry and the provision of green manure for rice farms of Gilan province and from there to Anzali wetland. In the last few decades, due to the increase in the entry of agricultural, domestic and industrial wastewater, as well as the decrease of the Caspian Sea, reed and *Azolla sp.*, there has been widespread growth and dispersal. Siahkeshim Protected Area, Selkehand Sorkhankol Wildlife Refuge are located in Anzali wetland.

Methodology. After reviewing 5 Landsat images in period of 1985–2018 with similar time

Table 1

Specifications of images used in this study

Row	Image ID	Sensor	Date
1	LT05_L1TP_166034_19850528	TM	28/5/1985
2	LT05_L1TP_166034_19950524	TM	24/5/1995
3	LE07_L1TP_166034_20070501	ETM+	01/5/2007
4	LC08_L1TP_166034_20130525	OLI	25/5/2013
5	LC08_L1TP_166034_20180523	OLI	23/5/2018

frames (May) in the study area, corrections were made on the images if necessary. The specifications of the images are visible in Table 1. Then, to separate the water body from the NDWI index [16] and the NDVI index [17] was used to calculate the vegetation surface and water withdrawal. The values of the above indices are varied from – 1 to 1 (1–2).

$$NDWI = \frac{GREEN - NIR}{GREEN + NIR} \quad (1)$$

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (2)$$

Respectively, the green and red bands of Landsat and NIR represent the near infrared band. Then, extraction results were analyzed. It should be noted that a 500 m buffer was applied to the final images to separate the vegetation cover of the wetland.

Results

The images of Anzali wetland water body from 1985 to 2018 are shown in Figure 2 (see color tab). The results of the comparison of the wetland area of the wetland between 1985 and 2018 indicate that the area of the wetland increased from 1985 to 2007 and decreased from 2007 to 2018. As you can see in Figure 3, the area of the wetland is given in different years per km^2.

The largest and the lowest area was respectively in 2007 (100.06 km^2) and 2013 (19.87 km^2). According to the 2007 image, in the same period in 1985, it has almost doubled, and it has the largest area in comparison with other years. The annual rainfall of 1985–2010 Bandar-e-Anzali rainfall station was depicted in Figure 4 in millimeters (based on Regional Water Company of Guilan). This station has the highest precipitation rates among Caspian Sea stations [15]. Anzali wetland survey showed that a large amount of wetlands was lost in 2013; according to the annual precipitation rates of the Bandar-e-Anzali rainfall station (Fig. 4), in the years leading up to 2010, this year the average annual precipitation fluctuated, despite a rise in 2006, it had a decreasing trend in 2007 (1360.8 mm).

We also observe that the area of the wetland in 2007 is about 70 km^2 more than 1985, about two decades ago. Landscaping images of the

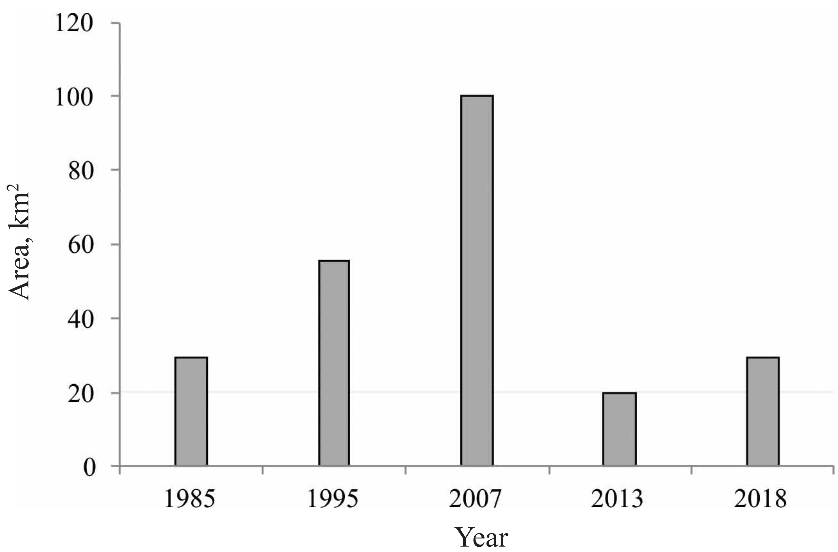

Fig. 3. Changes in Anzali wetland of water body by year, km^2

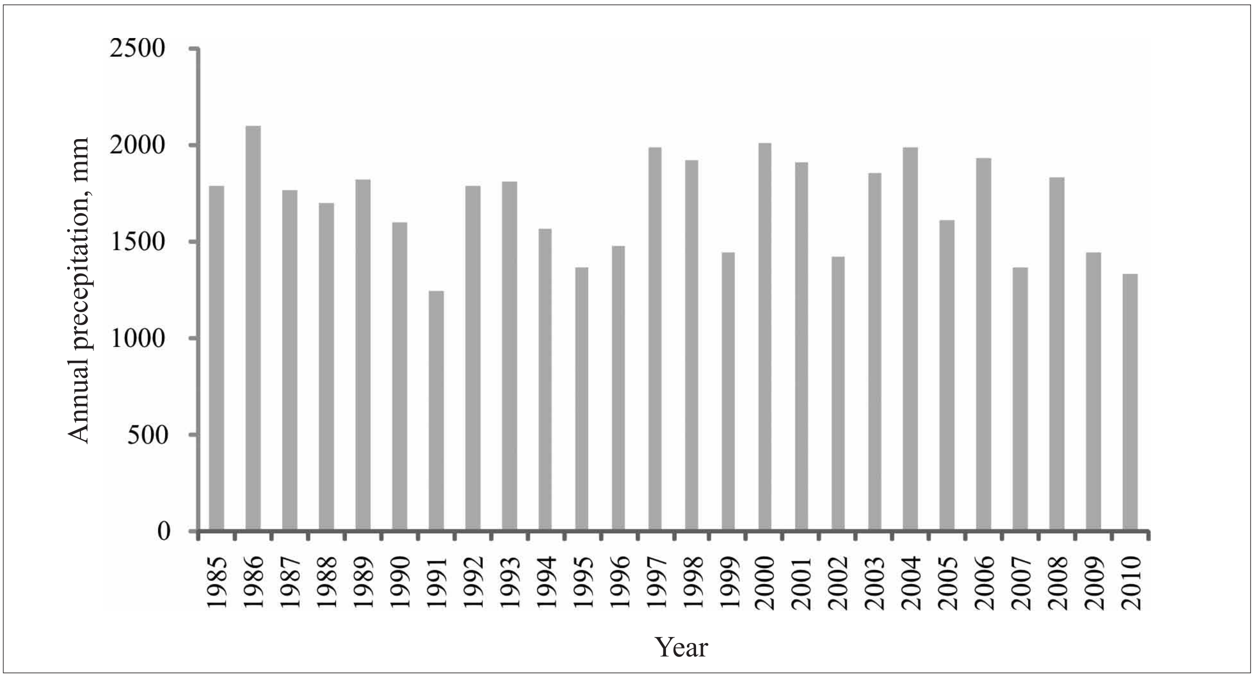

Fig. 4. Annual precipitation from 1985 to 2010 at Bandar-e-Anzali station, mm

vegetation surface and water withdrawal status of the wetlands by the NDVI index in 1985–2018 are shown in Figure 5 (see color tab).

Regard to the vegetation surface and water withdrawal map, in 2018, vegetation cover is less dispersed and less densely populated in the wetland, and in the years 1985 and 2013, vegetation cover was surrounded by the water body. Also, in 2007 and 1985, vegetation cover density of wetland can be seen. For a better study, the NDVI index graph in the years 1985–2018 is also calculated and is shown in Figure 6, and based on the results of the survey on the indice (NDVI), in cases where the wetland area is lower, the wetland vegetation cover density in these areas are less and vice versa. In 2007, the highest average value of the NDVI was achieved, and the lowest was in 2018.

Discussion

The trend of area change based on images (Fig. 2 , see color tab) indicates that the western part of the wetland has been aqueous during this period and has not significantly changed. On the other hand, the central part of the wetland had severe fluctuations, and it can be said that 2007 and 2013 had better situation, and in general, the eastern part of the wetland has a small water body.

Due to the Anzali wetland climate, rainfall increases from east to west, and the evaporation also increases from west to east [15]. Also in terms of topography of the wetland, the rate of water entering the eastern and central parts of the country drains is more than the west, which causes the fluctuations of the water body in the west of the wetland is less [12, 19]. The average drain of 10 major rivers entering the wetland is estimated to be 76 m^3/s or 2400 MCM (Million Cubic Meter), this is less in May and June (JAICA 2005). It should be noted that the taken images of this study belonged to this interval and had the same conditions. However, due to the region's climate (relative frequency of rainfall in the hyrcanian climate) and the relationship between Anzali wetland and Caspian Sea, fluctuations in the Caspian Sea surface affect the Anzali wetland hydrology [20–22]. Figure 7 (see color tab) shows the relationship between the wetland and the Caspian Sea (Retrieved from [23]).

The JICA report also significantly affects the Anzali wetlands› surface water level, indicating that discharge of river into the wetland had a small effect on wetland water change [24]. In this case, water movement direction in the Anzali wetland in the summer is from the sea to the wetland (water-rise) and reverse in the winter [25].

In the study of Mirzaei [26] in Gomishan wetland, it was observed that in summer, unlike temperature increase and evaporation, the amount of water in the Gomishan wetland increased and in the spring and summer, respectively, there was a receding of water and water-rise on the eastern shore of this wetland. The results showed that the water body of the

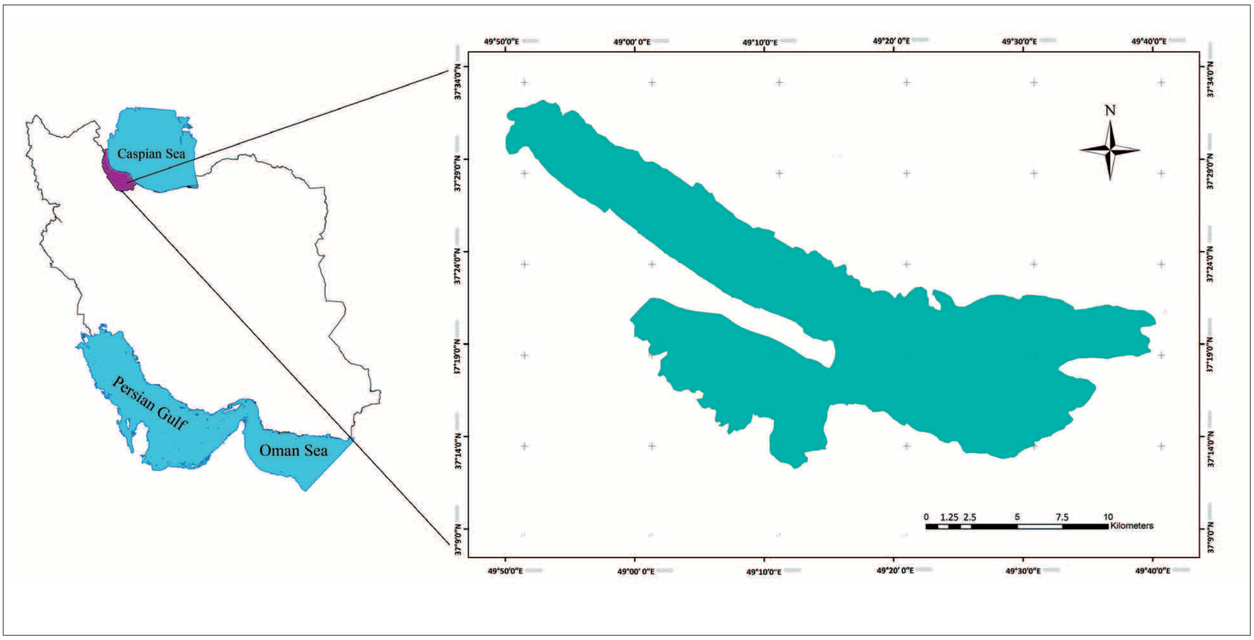

Fig. 1. Anzali International Wetland on the map

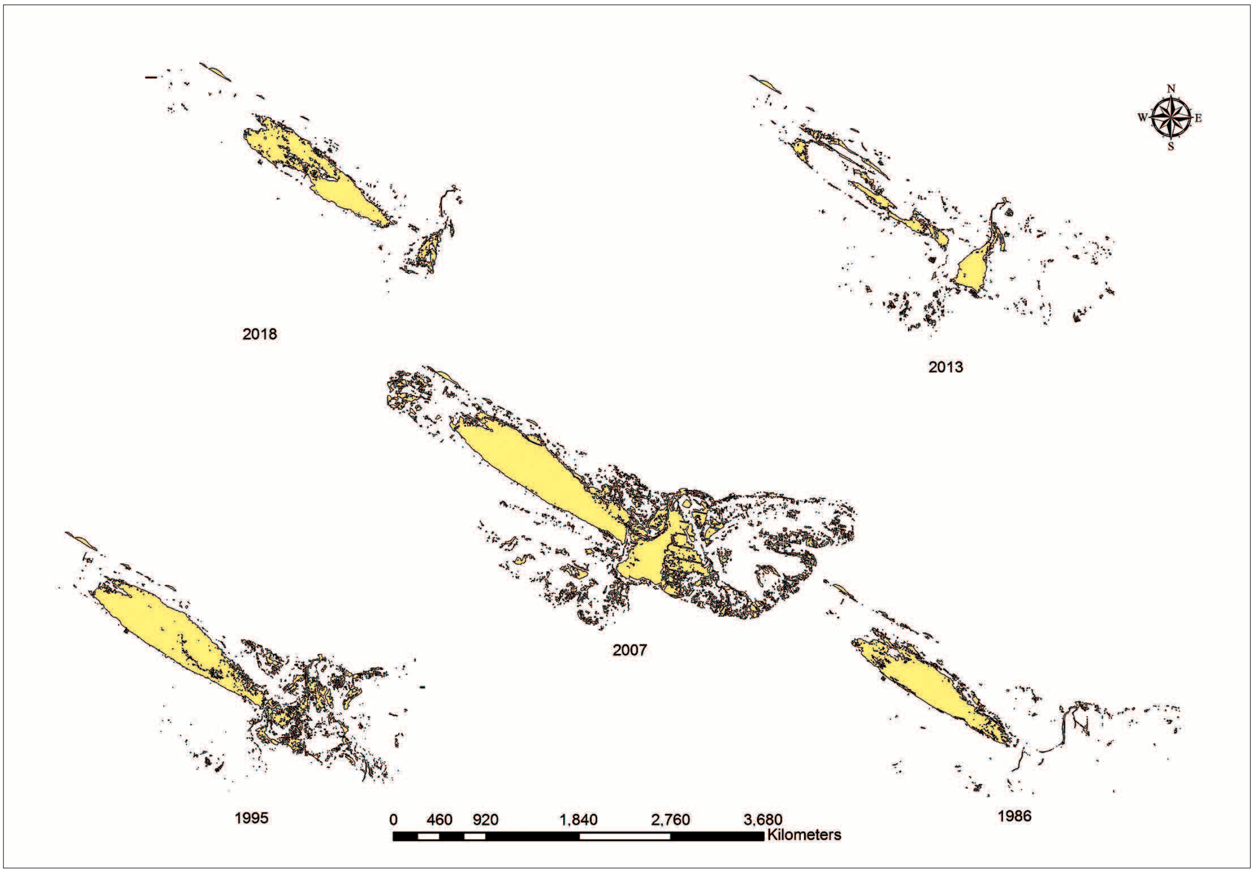

Fig. 2. Changes of water body in the Anzali wetland, by year

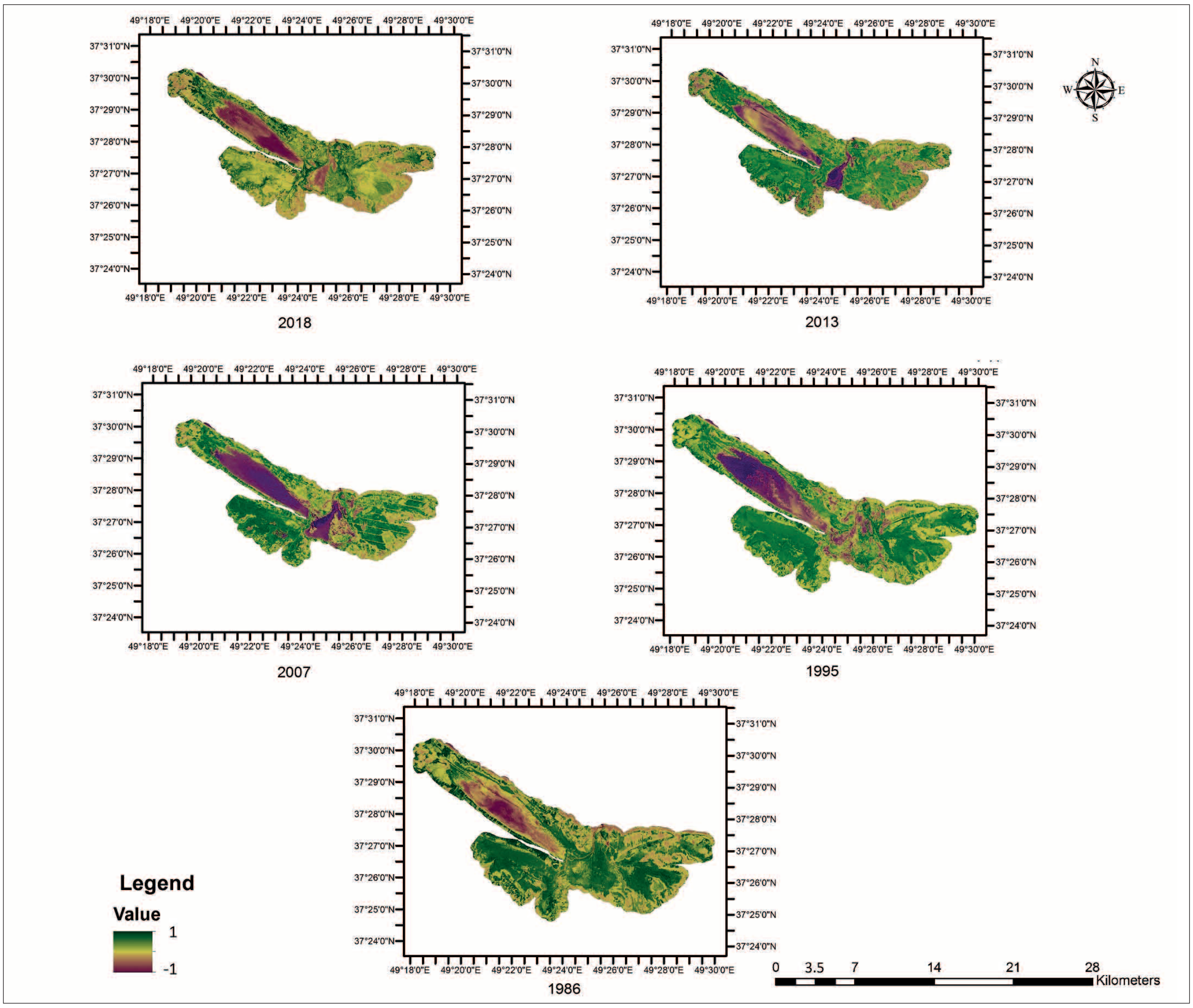

Fig. 5. Changes of NDVI in Anzali wetland, broken down by year

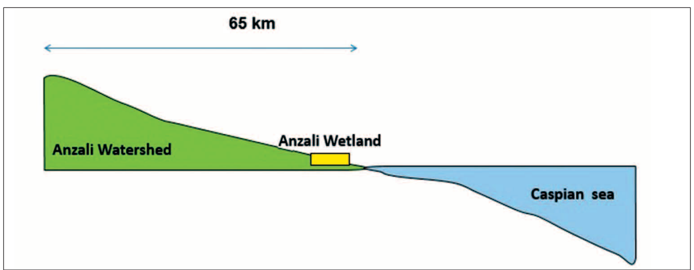

Fig. 7. Relationship of Caspian Sea and Anzali wetland (retrieved from [23])

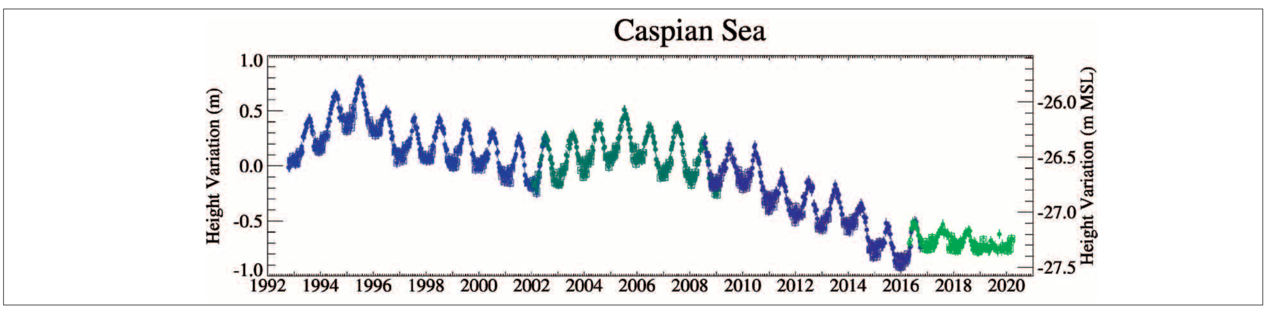

Fig. 8. Changes of sea level in the Caspian Sea 1992–2020 (https://ipad.fas.usda.gov)

Anzali wetland in 2007 was the highest despite the decreasing annual precipitation trend in 2007 (based on the data of the Bandar-e-Anzali rainfall station, Fig. 4). Therefore, in order to better investigation, the Caspian Sea surface was examined (Fig. 8 , see color tab) (https://ipad.fas.usda.gov). It should be noted that the Caspian Sea level is measured at the Bandar-e-Anzali, where the wetland is connected to the sea [15]. Regard to the figure, process of increasing the area of the wetland could be explained. In other words, the level of the Caspian Sea has begun to increase since the middle of the 70's and fluctuations are observed in the 1990s [27].

According to the previous reports [28] on Anzali wetland during the period 1940–1966, the area of the wetland reached from 259 km^2 in 1940 to 54.3 km^2 in 1966. On this base, the Caspian Sea level fluctuation is related to the area changing of the water body in the years of the study [28] and the present study. The trend was similar to the depth of the wetland, according to the studies [19], the depth of the western part of the wetland ranged from 11.8 meters in 1921 to 1–1.8 meters in 1974.

In fact, we can identify two periods according to the water body fluctuation: the period of the spread of the wetland (1985–2007), the period of reduction of the water body (from 2013 to today). Other involved factors which could be also as a threat to the wetland include high sedimentation rate of entering rivers into Anzali wetland.

According to statistics [11], 303 thousand tons of sediment is entering the wetland, which has the largest share in the country (upstream and highlands). 50% of which are deposited in the wetland and 50% enter the Caspian Sea [11].

But due to the human structures that have been created in the wetland in recent years (the construction of a bypass and a breakwater 2 in the direction of the outlet of the wetland), this natural process has encountered a problem and, as you can see, in 2013 and 2018, the surface area of water body of the wetland has decreased compare to the same period. According to experts, due to the sediment loading in the wetland, the decline in the depth of the wetland from 4–6 meters in the last few decades has reached less in some areas of the wetland [12]. According to Sabetraftar studies [29], the total sediments deposited in the wetland are estimated to be 539644 tons per year and 75 percent of it deposited. Due to its bulk density, more than 43,000 tons of wetland volumes are lost annually [30].

Hydrological studies also showed that the average sediment of mountainous areas is 110 tons per square kilometer, and in the plain and post area is 200 tons per kilometer, which is the source of more sediments in the wetland from the plains [12, 29].

The survey image of NDVI indexes shows that in the parts of water body of wetlands in 2013 and 2018, vegetation cover can be due to

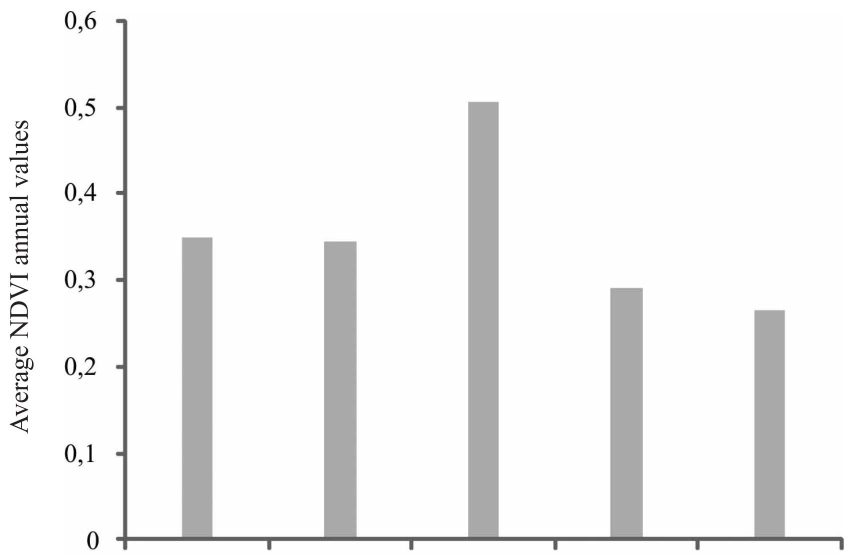

Fig. 6. Average NDVI annual values in the studied years

these environmental changes in the wetland. On the other hand, the growth of aquatic plants in the wetland has been increasing in recent years and the wetland is affected by a non-native species called *Azollafili coloides*, which is more than the other parts of the east and central [12].

Among other issues related to water body and vegetation cover, changes in the uses of wetlands in order to farming and cultivate rice (paddy field) can be mentioned. According to previous studies, the extent of vegetation cover in Anzali wetland depends on changes in the level of the Caspian Sea and its shelf life and influence. According to [19], the growth of plants on the coastline of the wetland increased during the period 1956–1974. For example, the *Trapanatans* trapped around the central part of the wetland, and in the later period, due to the development of emerge plants (*Phragmites* sp. and *Typha* sp.) dropped from the cover and reduced the water body during this period.

Drainage of water of wetland for agriculture and the entry of sediments and nutrients from the Sefid-Rud Basin, has led to an increase in sedimentation and delta building and the growth of macrophytes. Accordingly, after the construction of the Sangsar and Tarik dam from 1966–1985, due to the arrival and volume of high sediments, 1300 hectares was added to the area covered by the (*Phragmites* sp. and *Typha* sp.) and showed in the eastern part of the wetland.

Rainfall is one of the most important factors affecting vegetation, fluctuation and year-to-year variation will affect vegetation cover. In [9], there was a positive correlation between annual precipitation and vegetation cover.

In the study of Afrakhteh [30], the survey of vegetation changes in Hooral-Azim Wetland showed that the amount of rainfall effects in the area of the wetland and vegetation area is prominently evident. In the present study, in 1985, this trend and volatility observed in the following years.

Investigation of aquatic plant surrounding Anzali wetland shows that it is mainly influenced by the area of the water body, not to the precipitation rate. It is better to have vegetation in years where the area of the water body is greater. The growing increase of aquatic plants in the wetland should also be mentioned in this regard. Accordingly, considering that the western part of the wetland has a larger volume, most submerge plants, and vice versa, are often found in floating and emerge plants in the south and east [31]. In the survey image of the NDVI indexes, we see relatively more areas of southern and eastern wetland densities of vegetation cover. This is evident even though these areas are affected by urban wastewater and agriculture [11].

East of the wetland is the shallowest part of the wetland, and the aquatic plant growth in this part is very high and its depth is 0.8 to 1.5 m. Agricultural, industrial and urban wastewaters in this section have a large share (more than 70%) in contributing to the pollution of the wetland. In the eastern part of the 5 important rivers and drains enter the wetland, which are: Sheyjan, Ramzanbekandeh, Ghannadi, Lalehka, Bijroud River [11]. According to the present study, the expansion of farm lands in the margin of Anzali wetland and other activities such as livestock, fishing, the construction of fish farming ponds and other economic activities has led to changes and even aggressions to its bed and its buffer. Due to successive droughts and dam construction in recent years, fluctuations in the level of Caspian Sea water and unauthorized drilling and uncontrolled exploitation of groundwater resources and the construction of irregular watertight networks have caused the drying of the bed and receding of the wetland. Considering that the listed of Montreux Record is the wetland, in such a situation, it is necessary to seriously protect the buffer and determine its extent, and the fundamental consideration of changing human behavior in relation to the right to use buffer wetland, as a major dilemma and concern for water authorities is mentioned.

Conclusions

Inland waters, such as wetlands, are considered as sensitive ecosystems, which sustainable exploitation is possible only through adopting an appropriate environmental approach.

Considering that Iran is one of the dry countries, it is necessary to develop water resources that are usable and to maintain and improve their quality. Therefore, the knowledge of the dynamics of these resources provide the development of appropriate policies along to timely extracting information to minimize damage to these resources. The results of this study showed the effectiveness of this tool with the observation of NDWI and NDVI indices in identifying critical points and historical changes of Anzali wetland and better understanding of the dynamic conditions of the wetland during a 33-year period and can be used to adopt appropriate management and improve wetlands as a template for being used in other water sources.

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References

1. Tiner R.W. NWI Plus: geospatial database for watershed-level functional assessment // National wetlands newsletter. 2010. V. 32. P. 4–7.

2. Dahl T.E. Status and trends of wetlands in the conterminous United States 2004 to 2009 // Washington, D.C.: U.S. Dept. of the Interior, U.S. Fish and Wildlife Service, Fisheries and Habitat Conservation, 2011. 108 p.

3. Li J., Bai Z., Ling Z., Zongming W., Kaishan S. Current status and prospect of researches on wetland monitoring based on remote sensing // Progress in Physical Geography. 2007. V. 26 (1). P. 33–43. doi: 10.11820/dlkxjz.2007.01.004

4. Ma F., Wang Q., Zhang M. Dynamic changes of wetland resourcesbased on MODIS and Landsat image data fusion // Journal on Image and Video Processing. 2018. Article No. 63. doi: 10.1186/s13640-018-0305-7

5. Jin H., Huang C., Lang M.W., Yeo I.Y., Stehman S.V. Monitoring of wetland inundation dynamics in the Delmarva Peninsula using Landsat time-series imagery from 1985 to 2011 // Remote Sensing of Environment. 2017. V. 190. P. 26–41. doi: 10.1016/j.rse.2016.12.001

6. Özesmi S.L., Bauer M.E. Satellite remote sensing of wetlands // Wetlands Ecology and Management. 2002. V. 10. P. 381–402. doi: 10.1023/A:1020908432489

7. Baker C., Lawrence R., Montagne C., Patten D. Mapping wetlands and riparian areas using Landsat ETM+ imagery and decision-tree-based models // Wetlands. 2006. V. 26. P. 465–474.

8. Mac-Millan D.K., Splichal D.E. A review of field technologies for long-term monitoring of ordnance-related compounds in groundwater. Environmental Chemistry Branch, Environmental Laboratory, US Army Engineer Research and Development Center, Omaha, 2005. 60 p.

9. Thakur J.K., Srivastava P.K., Singh S.K., Vekerdy Z. Ecological monitoring of wetlands in semi-arid region of Konya closed Basin, Turkey // Regional Environmental Change. 2012. V. 12. P. 133–144. doi: 10.1007/s10113-011-0241-x

10. Jones K., Lanthier Y., van der Voet P., van Valkengoed E., Taylor D., Fernández-Prieto D. Monitoring and assessment of wetlands using earth observation: The GlobWetland project // Journal of Environmental Management. 2009. V. 90. No. 7. P. 2154–2169. doi:10.1016/j.jenvman.2007.07.037

11. Ministry of Energy. Surveying the Determination of Floodway and buffer of Anzali Wetland (Environmental Report), Iran Water Resources Management Company. 2011.

12. Mirzajani A.R. Limnological survey of Anzali wetland data during 1990–2003 by use of GIS system (Report No. 2009.111). Ministry of jihad-e-agriculture, Agricultural research education & extention organization, Iranian fisheries research organization, 2009. 123 p.

13. Evans M.I. Important bird areas in the Middle East. Cambridge, UK, Bird Life International, 1994. 410 p.

14. Azari F. Determination of the buffer zone of Anzali Wetland, Iran. Tehran. Environmental Protection Agency, 2009. 105 p.

15. The Wetland Book_ II_ Distribution, Description and Conservation / Eds. C.M. Finlayson, R. Milton, C. Prentice, N.C. Davidson. Springer Nature Press, 2018. 1966 p.

16. Khattab M.F.O., Merkel B.J. Application of Landsat 5 and Landsat 7 images data for water quality mapping in Mosul Dam Lake, Northern Iraq // Arabian Journal of Geosciences. 2013. V. 7. No. 9. P. 3557–3573. doi: 10.1007/s12517-013-1026-y

17. Chao Rodríguez Y., Anjoumi A., Domínguez Gómez J.A., Rodríguez Pérez D., Rico E. Using Landsat image time series to study a small water body in Northern Spain // Environmental Monitoring and Assessment. 2014. V. 186. P. 3511–3522. doi: 10.1007/s10661-014-3634-8

18. Azimi Yancheshmeh R., Riyahi Bakhtiari A.R., Savabieasfahani M. Oil contamination in surface sediment of Anzali Wetland in Iran is primarily even carbon number n-alkanes //Environmental Monitoring and Assessment. 2017. V. 189. Article No. 589. doi: 10.1007/s10661-017-6294-7

19. Kimball K., Kimball S. Limnology studies of Anzali Wetland. Technical Report. Department of Environment of Iran. Tehran, 1974. 114 p.

20. Mescherskaya A.V., Aleksandrova N.A. Caspian Sea level forecast from meteorological data // Russian Meteorology and Hydrology. 1993. V. 3. P. 52–60.

21. Nasrollahzadeh S.H., Bin Din Z., Yeok Foong S. Makhlough A. Trophic status of the Iranian Caspian Sea based on water quality parameters and phytoplankton diversity // Continental Shelf Research. 2008. V. 28. P. 1153–1165. doi: 10.1016/j.csr.2008.02.015

22. Caspian Environment Program (CEP). Regional action plan for protection of Caspian habitats, CEP. Iran, Tehran, 1998. 276 p.

23. Bagherzadeh Karimi M. Results of eological management project of Anzali Wetland // Workshop on wetlands management and engineering conference. Tehran, 2011. 15 p.

24. Japan International Cooperation Agency, "JICA". Integrated management for Anzali Wetland. Tehran, Department of Environment of Iran, 2005. 182 p.

25. Anzali jihad-e-agriculture Department. Report on the impact of Caspian Sea water fluctuations on coastal agricultural lands. Iran, Anzali jihad-e-agriculture Department Press, 2007. 95 p.

26. Mirzaei F. Investigation of the boundary of coastal area of Gomishan wetland using benthic fauna using GIS

(M.Sc. Thesis). Gorgan University of Agricultural Sciences and Natural Resources, Iran, 2012. 130 p.

27. Nemati Kutenaee M., Shahnazari A., Fazoula R., Aghajanee Mazandarani Gh., Perraton E. Effects of Caspian Sea water level fluctuations on existing drains // Caspian Journal of Environmental Sciences. 2011. V. 9. No. 2. P. 169–180.

28. Holčík J., Oláh J. Fish, fisheries and water quality in Anzali Lagoon and its watershed. Report prepared for the project – Anzali Lagoon productivity and fish stock investigations. Food and Agriculture Organization, Rome, 1992. 109 p.

29. Sabetraftar K. Anzali Wetland Protection and Restoration Project (Phase III). Environmental Protection Agencyof Guilan and Guilan University, 1999. 570 p.

30. Afrakhteh M. Dynamics of vegetation in the Hooral Azim wetland using remote sensing (M.Sc. Thesis) // Khoramshahr University of Marine Science and Technology Faculty of Marin natural resources Department of Environment, Iran. 2014. 115 p.

31. Nezami Sh. Bacterloplankton of Anzali Lagoon (Quantitative Survey) // Iranian Journal of Fisheries Science. 1995. V. 4. No. 1. P. 46–63 (in Persian). doi: 10.22092/isfj.1995.116248

ИБ Коми НЦ УрО РАН

УВАЖАЕМЫЕ КОЛЛЕГИ!

Приглашаем Вас принять участие в работе XVI Всероссийской научно-практической конференции с международным участием «Экология родного края: проблемы и пути их решения», которая состоится в г. Кирове 27–28 апреля 2021 г.

Программа включает проведение:

1. XVI Всероссийской научно-практической конференции с международным участием «Экология родного края: проблемы и пути их решения» (27–28 апреля 2021 г.).

Конференция будет проходить в гибридном формате: очное участие и online. Работа конференции включает проведение пленарного заседания и секций.

Основные направления работы конференции:

1. Экологические проблемы региона.
2. Экологический мониторинг состояния окружающей среды.
3. Химия и экология почв.
4. Экология микроорганизмов.
5. Биология и экология растений.
6. Биология и экология животных.
7. Цифровые технологии в экологии.
8. Экологическая этика и культура в современном обществе.

2. Регионального молодёжного конкурса экологических плакатов «Моя чистая страна» (27 апреля 2021 г.).

Мероприятия конференции организуют и проводят ФГБОУ ВО «Вятский государственный университет» совместно с Институтом биологии Коми научного центра Уральского отделения РАН.

Информация о конференции и конкурсе, регистрационная форма участника и требования к оформлению материалов размещены на сайте
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