Land-use changes in coastal areas of Gorgan gulf Using Multi-Time satellite data

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abstract:

The use of coastal lands is constantly changing due to the regression and progress of water areas. This coastal Land change uses the need for continuous monitoring at regular intervals to efficiently manage coastal resources. In this study, the effect of Gorgan gulf progress and regression on land-use change in the surrounding lands has been modeled and estimated using remote sensing images. For this purpose, two satellite images of Landsat 5 and Sentinel 2 were taken in 1992 and 2017, respectively, and after preparing and applying the necessary preprocessing, the most similar classification and land uses of the study area were extracted. Overall accuracy values of 0.94 and kappa coefficient of 0.92 indicated the appropriate accuracy of land use maps. The classified images and the topographic maps, and the network of passages of the study area were designated as land modeling inputs to detect land-use changes over 25 years. The study results showed that the water area of the Gorgan gulf had faced a water level decline of 150 square kilometers, which has led to an increase in the area of wastelands. Also, agriculture and garden, and rangelands have been significantly reduced during the study period.

Keywords: Change Detection, Landsat 5, Sentinel 2, Remote Sensing, Gorgan gulf

1.Introduction

It is estimated that more than 40% of the population of human communities live in or near coastal areas (Carter, 1998). Rising sea levels and their progress and regression on the coasts and bays as one of the manifestations of climate change constantly threaten coastal destinations and bays. Floods and flooding of coastal areas, coastal erosion, damage to infrastructure, destruction of coastal facilities, and increased human hazards are all threats that cause rising sea levels (Memari, 2014); Therefore, studying the effects and consequences of this progress and regression on the coastal strip lands can be used to better understand this natural process in order to deal with the destructive effects, in other words, to decide on better planning for land resources and landscaping in these areas. Lead to adaptation to changes imposed on Land at regular intervals. Considering the need to recognize the effects of regression and progress of areas near the sea on land use in adjacent areas, monitoring and detecting land-use changes in coastal areas resulting from these sea-level fluctuations is of great importance. Despite the importance and abundant resources that coastal areas have always provided cheaply to coastal residents, human activities have always imposed damage and pressure on the lands of these areas. Today, natural resource satellites are the most common source of remote sensing data. Quantification and mapping are patterns of land-use change (Abd El-kawy et al.; 2011). Effective land resource management at a watershed level is highly advantageous in achieving long-term sustainable development goals (Gajbhiye et al., 2015). Predicted land-use changes exhibiting major modifications and alternations can help land-use planners, resource managers, and conservation officers promote sustainable land management and mitigate negative impacts. Consequently, detecting and predicting land-use changes has become an essential consideration in various fields, including modeling rural and urban plans (Kumar, P et al.,2013)(Theobald, D.M et al., 1998). Determining the process of converting land use to other uses with dynamic information extracted and estimated from the application of various quantitative patterns on remote sensing images ,Including the use of change detection techniques, can lead to mapping information and analysis of user changes. Detection of coastal land changes is one of the basic needs in the management and planning of these areas, One of its methods, considering the scale and pre-drawn goals, is to prepare a map of changes based on multi-time remote sensing images. Coastal areas, or in other words, areas where the interaction of land and naval forces is effective, are affected by the wide range of geological, hydrodynamic, and climatic phenomena along with human activities, which result in a very variable and active face of these forces. The occurrence of some phenomena causes many problems in the economic and social affairs and activities of the watersheds of the country's coastal areas, such as the rising sea level and the sinking of thousands of hectares of coastal lands. Sedimentation in ports and

coastal structures of the country, extensive erosion of coastal lands, and pollution of water and soil resources of beaches, wetlands, and bays. For example, as the largest lake globally, climate change has also affected the Caspian Sea. All of these Threats and opportunities faced by coastal residents and changes that occur much faster than other areas in coastal areas and change the face of Land uses and even the emergence of Land are uses that have not been seen before. Raises the need for continuous monitoring and integrated management of these valuable areas.

1.2background research

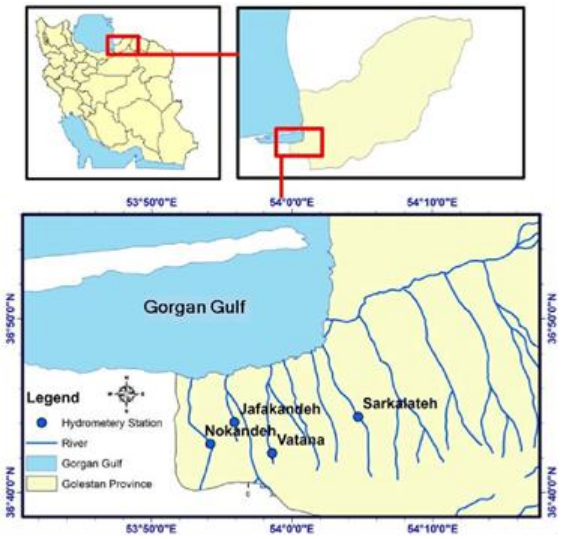
Anqangarmeh and Malek studied aspects of peaceful coexistence with Caspian Sea water fluctuations to sustain Iranian coasts. They first examined the trend of changes in the Caspian Sea water level in the long-term, medium-term, and short-term periods and the predictions made about the fluctuations and the amplitude of sea fluctuations in time scales. The range of oscillation of this show and the existing rules were transferred with it, and finally, to optimally exploit the coastal area, a suitable model and appropriate management were proposed according to the fluctuations of sea level. The results obtained from the study of Caspian fluctuations showed that its oscillation amplitude has different intensities in the studied time scales (Anqangarmeh and Malek, 2005). Qanavati et al. in 2007 studied the geomorphological and land-use changes of Khormousi and adjacent coastal areas using methods based on remote sensing and GIS. Moreover, fuzzy logic was used to implement their change method and mapped the degree of severity of changes in different points and phenomena in the region (PCA). The results showed that most of the changes in natural phenomena have occurred around the coastline and the islands inside Khormousi. Also, during the study period, many changes were made in the land uses of the coastal cities of Mahshahr and Bandar Imam. These changes included the development of Imam Khomeini port and huge petrochemical facilities and affiliated companies, a special economic zone and the construction of an airport, And the expansion of urban centers in the region during the period studied from 1991 to 2003(Qanavati et al., 2007). Ayad, in 2005 evaluated the visual changes that occurred in the coastal areas of Egypt with the help of remote sensing data, aerial photographs, and raster modeling in the environment (GIS). Based on four visual indicators of vegetation diversity, The activity, close to the shores and topographic changes, obtained a composite index, based on which it identified three types of visual resources in terms of naturalness and pristine nature (Ayad, 2005). other researches have been conducted in this field (D. A., Dennison, et al.,2007) (Huang,2002) (Haibin,2010) (Aronoff, S, 1989) (rahimipor et al., 2005) (sharyari et al., 2008)(shafiei et al., 2004). Wu et al. in 2006 used a combination of GIS and remote sensing to study land-use change occurring continuously in Beijing. Their findings indicate a significant increase in urban land use and a decrease in rangeland-covered areas between 1986 and 2001(Wu et al., 2006). Vaclavik and Rogan in 2009 used Land Change Modeling (LCM) to detect changes. The results showed that 6% of mixed forest land was converted to cotton, and 3.5% was added to the residential land area. Khoi and Murayama (2010) implemented land change modeling and artificial neural networks to model forest land change. They used satellite imagery from 1993-2002 to 2007 to detect and predict forest land changes in 2014 and 2021. Their results showed that the area of forested land decreased significantly between 2007 and 2021. Will be accompanied (Vaclavik and Rogan, 2009). Ahmed et al. in 2017 studied the dynamics and changes of coastal land use in Bangladesh by adopting a management method based on the integration of remote sensing and gis. They concluded that combining future challenges of the study area with hydrodynamic scenarios combined with measurement techniques From afar and gis for further analysis of the dynamics and integrated management of coastal lands can be fruitful (Ahmed et al., 2017). Karaj et al. in 2017 studied land-use change and conversion of coastal areas using remote sensing and GIS. They used it most likely in their study through the facilitator and concluded that over the past decade, the increase in a residential area, which has been directly proportional to the population growth of the area, has had a devastating effect on coastal resources (Kaliraj et al., 2017). Oktavianto Gustin et al. in 2019 Regarding the diagnosis of land-use change, the percentage of land-use change area from 2010 and 2016 in Batam Island was determined by determining the relationship between land-use change with an overall accuracy of 88% (Oktavianto Gustin et al., 2019). Also in 2020 Gulam Munna et al .They were able to show that the rate of change in the city of Silhat lost 7.41% of water between 2006-2019.(Gulam Munna et al. 2020). another research Solomon Mulat et al.in 2020 showed the land-use changes that took place between 2002 and 2010 in East Twente, the Netherlands, which showed that the major change was related to agriculture, which has become a developed area (Solomon Mulatet al.,2020). Also, Boubacar Solly, To study the evolution of land use and land cover changes in Upper Casamance, used Landsat images used in 1987 and 2018 to classify the method (K-means) and examined 15 classes(Boubacar Solly et al.,2020). Dires TewabeDires Tewabe showed that in the last 32 years, agricultural lands and residential areas in the basin have increased by 15.61 and 8.05 percent, respectively (Dires Tewabe et al.,2020). another approach J Himanshu Rao: Creating a land use/land cover map of the catchment (Kiknari Nala), a branch of the Brenner River Basin. They showed that most areas of the basin are covered by agriculture (33.85%), followed by fallow lands (27.07%) and forests (22.53%) (J Himanshu Rao et al.,2020). other researches have been conducted in this field (Rajesh. J et al.,2014) (Maher M. Amin et al.,2018). In 2021 Liang Guo Land use monitoring/cover change Guangzhou China from 1986 to 2018 using supervised classification using random forest classification. They showed that the vegetation reduction area has largely become a built-up area (Liang Guo et al.,2021). Sonam Wangyel Wang et al. in 2020, they used to identify and predict land-use change and land cover changes in one of the most vulnerable and fast-growing cities of Kathmandu in Nepal in the world, which found that for 20 years (from 1990 to 2010). The significance of these damages has been absorbed by urban developing areas, which have acquired 52.47% of the Land. Forecasts for land use and land cover change for 2030 show

that forest, agricultural, and water uses are declining by 14.43%, 16.67%, and 25.83%, respectively, with the largest increase for urban areas at 18.55%. In the nose (Sonam Wangyel Wang et al.,2020). Other researches have contributed to improving this field (Kawser et al., 2019) (Asirat Teshome et al.,2020)(Darshan Sansare et al ., 2020)(Md Moniruzzaman et al ., 2020)(Sandipta Das et al., 2021)(Muhammad Usman Liaqat et al., 2021)(Jean Paul Nkundabose et al., 2021)

2.Materials and methods

2.1.The area of study

Gorgan Gulf is located in the southeastern part of the Caspian Sea in Golestan province. Changes in the water level of the Caspian Sea in the coastal areas of the Gulf over time, due to changes in land use and pattern of use in these areas and even adjacent areas Is. The area of the Gorgan gulf is about 400 square kilometers. Gorgan Gulf is shallow, so that considering the high water readiness, its maximum depth reaches 4 meters. Although Gorgan gulf has become a protected area, the existence of uncontrolled and untimely fishing, increasing imports of industrial, livestock, and agricultural wastes on the one hand and the environmental importance of Gorgan gulf and the need to use more food resources for the country's population, on the other hand, It is one of the issues that we studied in this regard. Figure 1 shows the geographical location of the study area.



(Figure 1) The geographical location of the study area

2.2.The research process, data, software used

The basis of calculations and processes required for modeling land-use change in the study area was remote sensing images with medium spatial resolution, application of classification techniques, land change modeling, and some spatial analysis functions in the GIS environment. Other data used in this study were: 25000 global maps obtained by the Iranian Mapping Organization with the interpretation of 1: 20000 scale aerial photographs and the location information of communication lines and roads in the Gorgan gulf area. The source was the Open Street Map service. Other data and reference information in this study include topographic information of the study area. Tables 1 and 2 show the data and information used in this study.

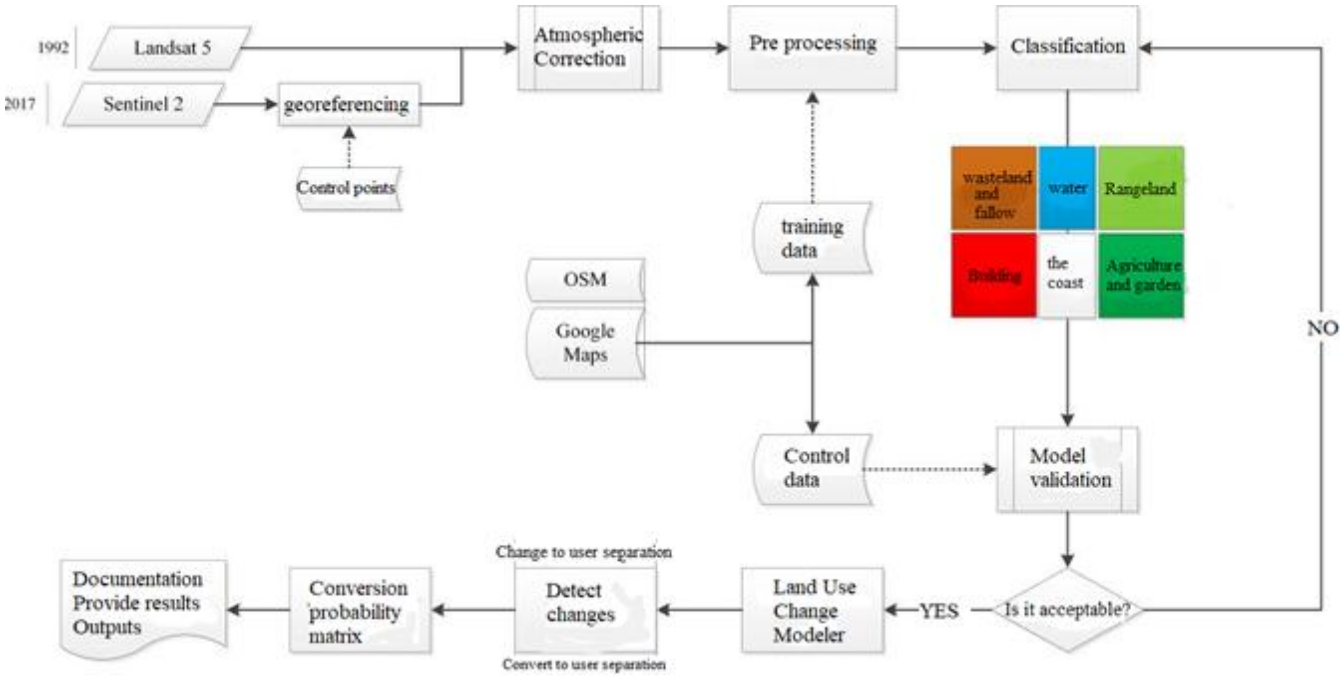
Data	Usage	Source
Sentinel 2 image	Classification and extraction of uses	European space Agency
Landsat 5 image	Classification and extraction of uses	United States Geological Survey
Map With a scale of 25000	Land maps	Iran National Cartographic Center
Lines of Comminication	Distancing from roads and modeling land use changing	Open Steet Map
Topogeraphy map	Modeling usage changes	Iran National Cartographic Center
Meteorologival data	Meteorologival information	Iran Meteorologival Organization

(Table 1) Characteristics of data and information used in the research

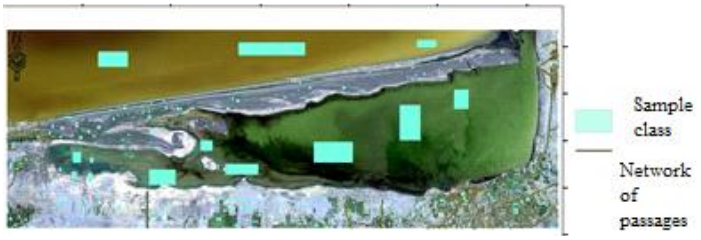
Satellite	Number of Bands	Data Taken	Spatial Separation (m)
Sentinel 2	12	8/8/2017	10,20,50
Landsat 5	11	14/08/1992	15,30

(Table 2) - Characteristics of images used in the research

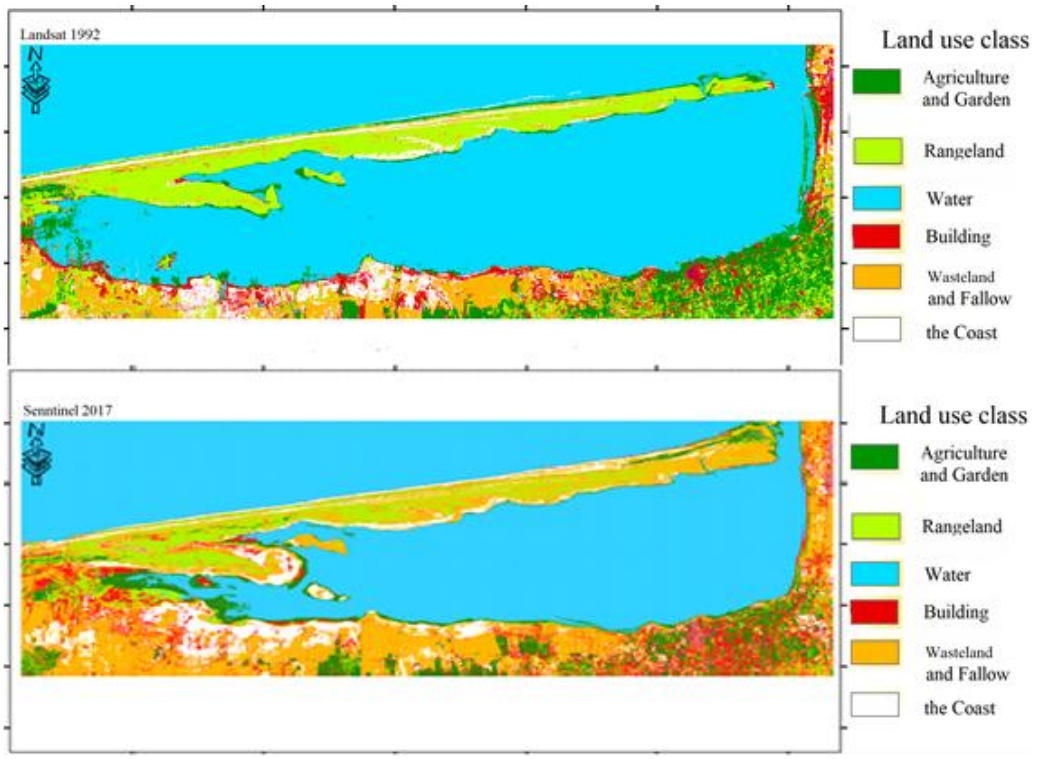
The software used in the present study included ArcGIS, ENVI, and Idrisi. The research process began with receiving Landsat 5 and Sentinel 2 remote sensing satellite images. After receiving the images, preparing them for applying classification patterns, and finally extracting land use information, preprocessors required on They were applied in the ENVI image processing software environment. These preparation steps included performing image band sorting, ground reference, and geometric and radiometric corrections, cutting, applying sharpness-enhancing filters, and creating the required color combinations. After performing the image preparation and preprocessing steps, the most likely classification algorithm was used to represent the parametric supervised classifiers on the preprocessed image bands. The above algorithm was applied to both categories of images taken in 1992 and 2017, respectively, and the outputs of their application were land use maps of the study area in two spatial divisions of 30 and 10 meters, respectively. Where the result of image processing. In order to apply and evaluate the accuracy of the above classification methods, it was necessary to sample various uses and features that could be detected in the images. Twenty-five thousand reference maps were used. Educational and experimental data were placed in six and five different groups for images, respectively. Half of the sampled data were used to implement the classification algorithm; If the outputs were used to assess the accuracy of land user classes. After applying more classifiers Like the images, land use maps were obtained at the time of image capture. To evaluate and confirm the accuracy of the results and outputs indicating the position and level of user classes, the error matrix is formed based on the experimental data collected in the previous steps, and the accuracy evaluation parameters for each of the uses and classification methods separately Has been calculated. After validating the results, the land use map of the area and the margin of the Gorgan gulf, including "agricultural and garden," "rangeland," "water zone," "built," "wasteland," and "coastal" landscapes, were prepared. These maps and topographic information layers, and the network of passages of the study area were used to input the land-use change modeling module (LCM). After modeling and detecting land-use changes, the study area of parameters and committees representing different aspects of changes in 25 years was calculated and prepared. These aspects mainly included the area and ratio of changes and transformations between Land uses, the net changes of each land use, and the matrix of the probability of conversions between Land uses for each given future land use. In the end, land-use changes and the role of Gorgan gulf surface changes, including the progress and regression of its coast in other land-use changes, were analyzed. Figure 2 shows the general stages of the study, and Figure 3 shows the position of educational and experimental samples for classification in the study area. Figure 4 Running user maps show the maximum likelihood on Landsat5 and Sentinel 2 images, respectively Table 3 shows the error matrix for the maximum likelihood classifier evaluation performed on Sentinel 2 images. Due to the Lack of access to reference data for 1992 image accuracy, the 2017 land-use class accuracy survey results, considering that both types of classifiers are used, to the 1992 Landsat 5 image classification results Were attributed. The values of the two parameters are the overall accuracy, and The kappa coefficient is shown in Table 4. In Table 5, the values of manufacturer accuracy, user accuracy, and deletion errors, and other errors are also given Listed separately for user classes.



(Figure 2) Flow chart of the process of implementation of research stages



(Figure 3) Spatial dispersion of educational and experimental samples



(Figure4) Land use map resulting from the maximum likelihood classification on the Landsat image in 1992 and the Sentinel2 in 2017

Land use calss	Reference Effects					
	Agriculture and garden	Rangeland	Water	building	Coast	Wasteland and fallow
Agriculture and garden	4539	1	4	8	166	9
Rangeland	0	737	0	18	2	5
Water	13	4	661	0	0	19
building	2	108	0	1061	0	11
Coast	50	0	0	0	2060	13
Wasteland and fallow	5	34	152	37	92	4037

(Table 3) Error matrix for the most likely classifier on the Sentinel 2 image

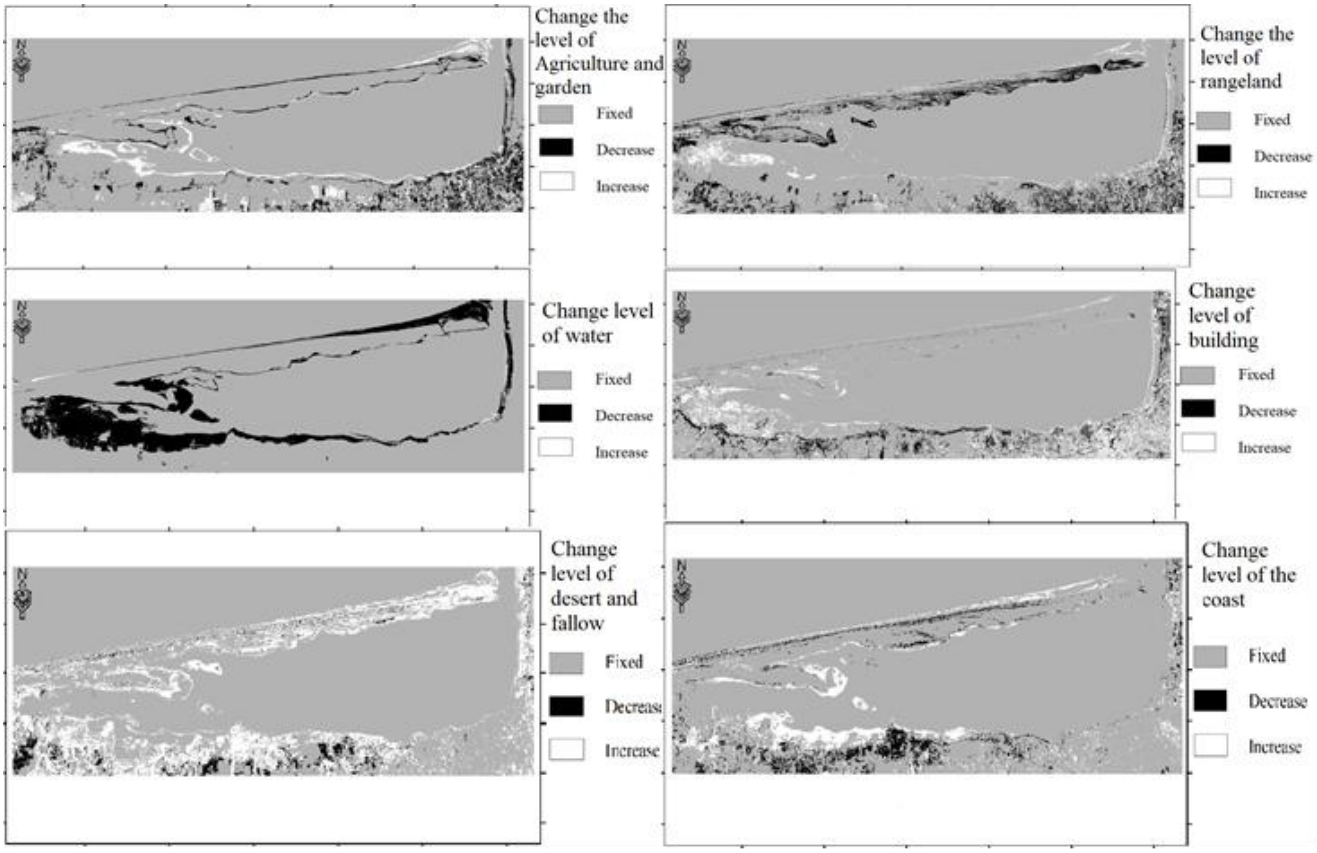
Classified image	Sentinel2	
Accuracy statistics	Kappa coefficient	Overall Accuracy
	0.92791	0.94562

(Table 4) Total accuracy values and kappa coefficient for the maximum likelihood classifier

Image	Accuracy Parameters				
	Land use class	User Accuracy	Extera Error	User Accuracy2	Delete Error
Landsat5	Agriculture and garden	0.8178	0.1822	0.8804	0.0156
	Rangeland	0.7888	0.2112	0.9844	0.0156
	Water	0.9605	0.0398	0.9848	0.015
	building	0.8892	0.1108	0.9558	0.0442
	Coast	0.6791	0.3209	0.3209	0.0811
	Wasteland and fallow	0.973	0.027	0.9972	0.0028

(Table 5) Manufacturer accuracy values, user accuracy, and deletion and addition errors

Figure 5 shows the plans to change the land use level in three modes of area reduction, area increase, and surface stability. Table 6 shows the values of increase, decrease, and change in the net area by types of Land uses identified. In general, the first point that can be seen about the estimated land-use changes is the decrease of more than 21% in Gorgan gulf and its surrounding areas, and of course, a slight increase in its area compared to this significant decrease. So that the water areas of the study area, mainly the Gorgan gulf, have been faced with a net decrease of 150 square kilometers during these 25 years. On the other hand, this decline of the Gorgan gulf surface during the last three decades has been the source of fundamental changes and developments in other land uses. So that the wasteland and fallow Land use with more than 150 square kilometers and a relative net increase of 70% from this perspective have been more than any change of use. In addition to reducing water areas, agricultural, garden, and rangeland lands have also faced a significant reduction in the area during these 25 years. On the other hand, except for wastelands, coastal and built land uses have experienced a significant increase in area.



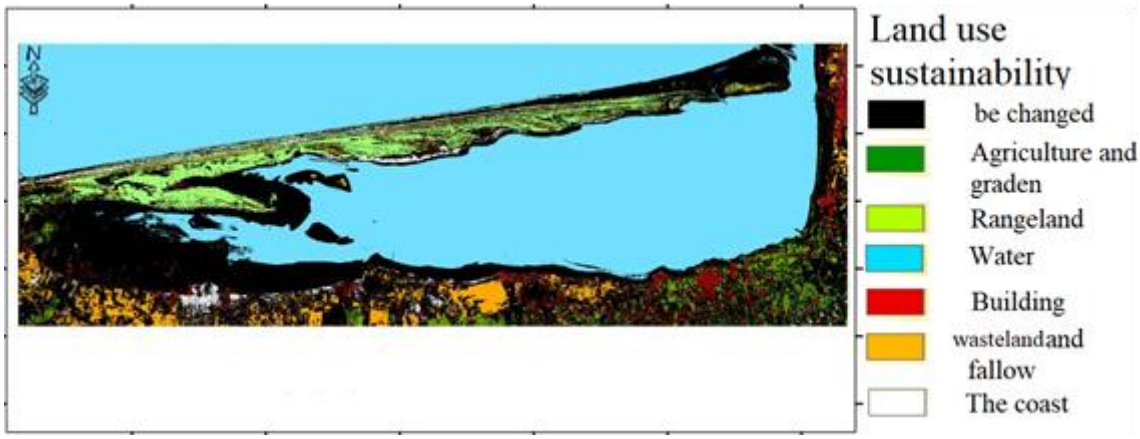
(Figure 5) Map of Land-use changes

In Table 7, you can see that the water zones are all negative values , and for the use of wasteland and fallow lands, all the values are positive, which means that in the water zones, all the changes have been towards the creation of other uses, which is reflected. The reduction of 150 square kilometers has been mainly the surface of the Gorgan gulf in the period under study. The most significant increase in area was from irrigated areas to coastal lands, while the most significant increase in the wasteland and fallow lands was from satisfied rangelands.

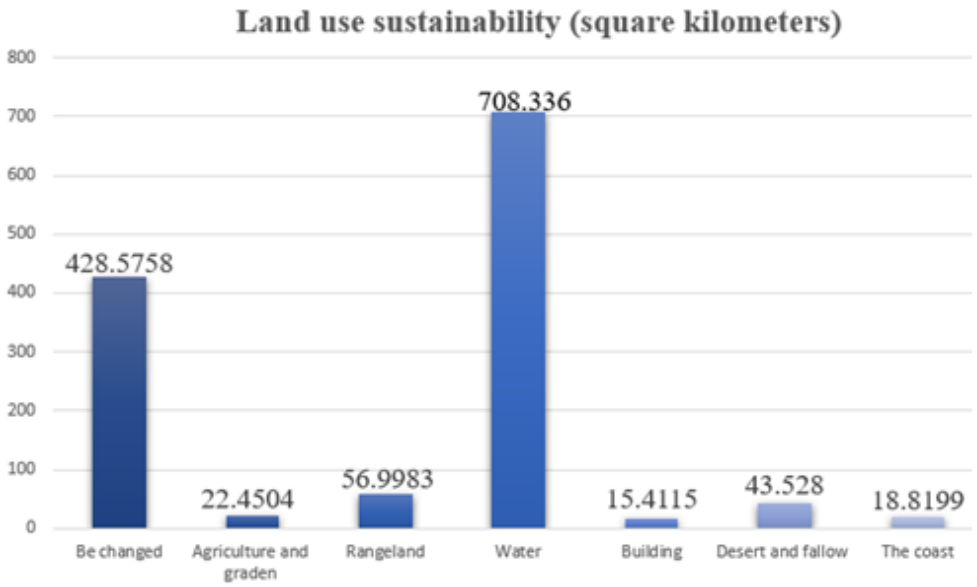
Land use Calss	Level Change (Km^2)		Change in net area (Km^2)
Agriculture and garden	56.13	Increase	-16.72
	72.85	Decrease	
Rangeland	40.14	Increase	-51.48
	91.62	Decrease	
Water	1.55	Increase	-149.2
	150.75	Decrease	
building	82.05	Increase	38.59
	43.46	Decrease	
Wasteland and fallow	177.56	Increase	154.11
	23.44	Decrease	
Coast	70.29	Increase	24.7
	45.59	Decrease	

(Table 6) Increasing and decreasing change of land use area (square kilometers)

Figure 6 shows the stability map of lands, meaning the stability of areas immune to change in these two nodes. Table 7 also shows the area free from land-use change by land type. Although water areas have shown the highest level of stability, it should not be overlooked that this land use has the highest level so that the rate of change in the levels of other land uses is much lower than the area stability of water areas. Finally, figure 7 shows the maps of the conversion from one application to another.



(Figure 6) Land use sustainability map



(Table 7) Stability values of land use level by land type

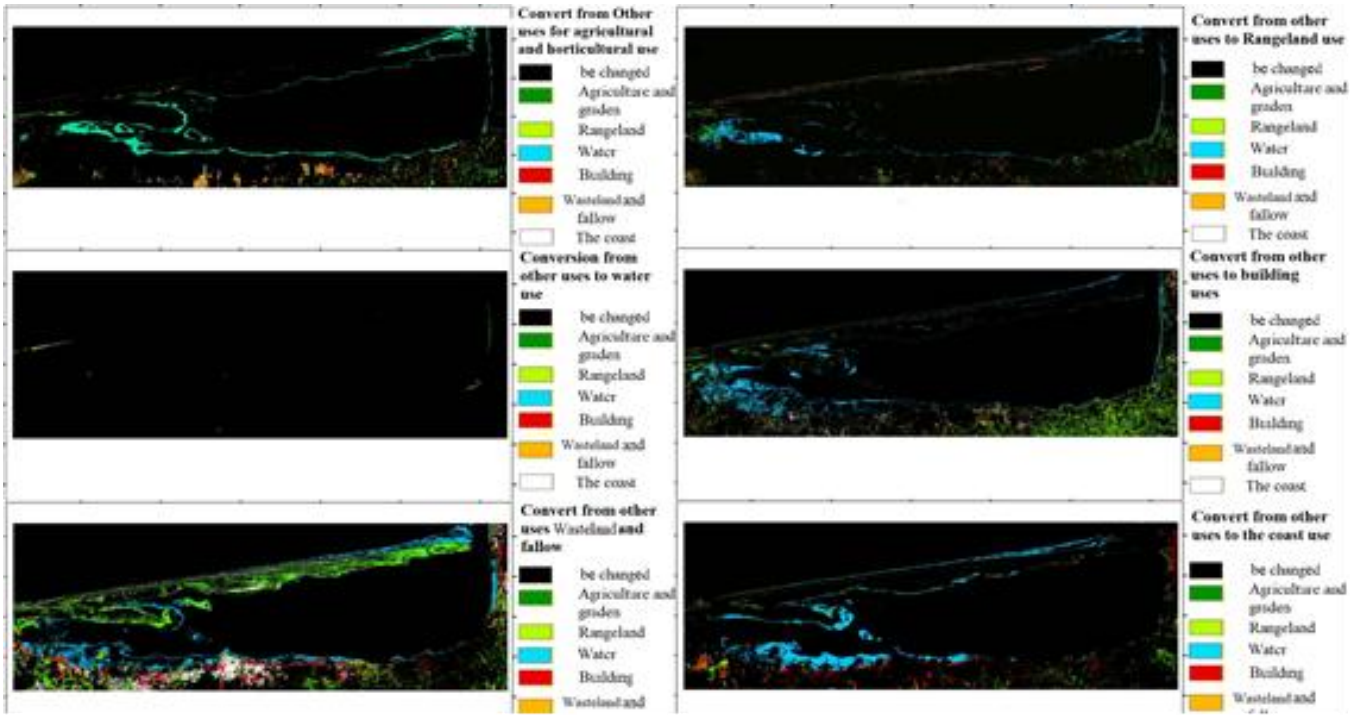


Figure 7 - Map of conversion of Land uses to Other Uses.

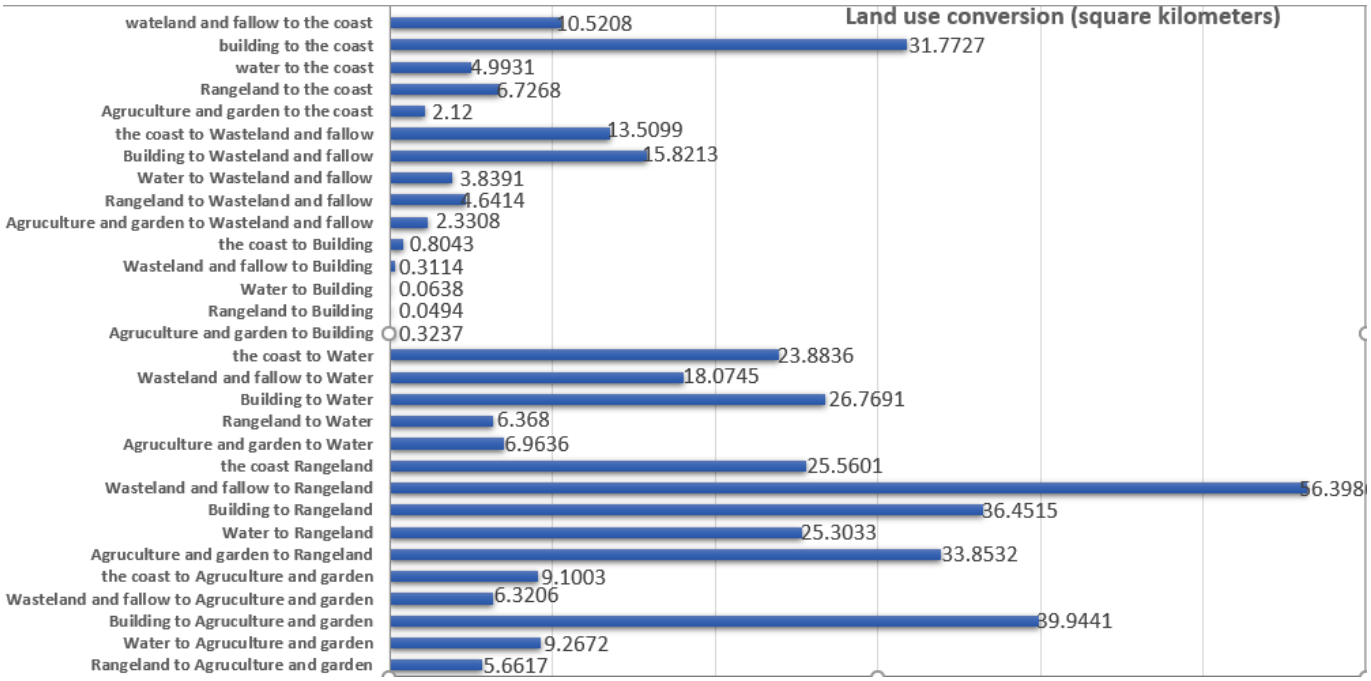


Table 8 shows the conversion diagram between uses, breaking the conversion level from one user to another. This form complements and confirms the other findings mentioned above. The highest conversion level was related to the change from pasture use to wasteland and fallow land use, while the lowest area was converted from wasteland and fallow land use to water areas.

2.3.Findings of land-use change detection

At this stage, land use maps were modeled in two-time nodes 1992 and 2017, and after confirming the accuracy, the maps entered the Idrisi software environment as land-use change modeling inputs. One of the critical and practical outcomes resulting from implementing the land-use change modeling matrix is the probability of conversion between Land uses in pairs or pairs (Table 7). The numbers on the primary diameter of this matrix indicate the probability of conversion between two identical users, which have the highest values as expected, but on the other hand, the arrays indicate the probability values between non-identical users. Table 9, which shows the mentioned matrix based on the trend of changes estimated over 25 years for 2030, shows that with the continuation of this situation, the regression trend of the wide range Gorgan will continue so that there is the slightest chance of returning from other uses to water areas.

Land use class	Agriculture and garden	Rangeland	Water	building	Wasteland and fallow	Coast
Agriculture and garden	0.329	0.1497	0.0072	0.3004	0.1386	0.755
Rangeland	0.054	0.5214	0.0012	0.1093	0.3023	0.0121
Water	0.03	0.0097	0.9027	0.0173	0.0052	0.035
building	0.0078	0.0482	0	0.3488	0.3578	0.1718
Wasteland and fallow	0.096	0.0503	0	0.0689	0.7171	0.0677
Coast	0	0.0126	0.0042	0.0987	0.4854	0.3991

(Table 9) Matrix of the probability of land-use conversion to each other in 2030

2.4.The effect of Gorgan gulf regression on land use levels

The surface of Gorgan gulf is covered by the use of water in the classified maps, and as the revelation of land-use changes in the period 1992 to 2017 shows that the construction of Gorgan gulf has decreased by 150 km; In other words, the result of what has happened to Gorgan gulf in these three decades has been seen as a setback. To observe the effects of this regression on the surface covered by other Land uses, land-use conversion maps are explicitly used to convert water area land use to other Land uses. These values are shown in Table 8, leading to Table 10 for convenience. In general, coastal and wasteland land uses have occupied more than half of the converted surface of the Gorgan gulf during the study period. If agriculture and horticulture are built, and pastures in this regard are in the following ranks.

Use Formed	Converted Area (Km^2)
Agriculture and garden	31.17
Rangeland	15.82
building	26.76
Wasteland and fallow	36.45
Coast	39.94

(Table10) Increased area of Land resulting from the decline of Gorgan gulf

3.Conclusion

The main stages of the study were carried out in three parts. In the first step, remote sensing satellite images were received in 1992 and 2017, and the required data were received from the desired sources; and after applying the necessary preprocessing and preparations such as Atmospheric corrections entered the next stage, which was the classification of images to identify the land use of the study area. Satellite imagery included Landsat 5 reflective bands in the visible, near-infrared, and mid-range range taken in 1992 and visible and near-infrared bands taken in Sentinel 2 in 2017. At this stage, land use maps in the two-time nodes of 1992 and 2017 using the classifier of the most similar modeling and, after confirming the accuracy, entered the Idrisi software environment as inputs of the land-use change modeling module. The uses that were estimated and extracted in this study were based on the purpose and scale of the study, the capability of the satellite images used, and the natural state of the study area and included six uses: "agricultural and horticultural," "rangeland," "water zone.", "Built," " wasteland," and "coastal." The process of detecting land-use change as the most critical stage of the study highlighted many aspects of land change during the last three decades, mainly based on a pairwise comparison of Land uses in two-time nodes and other parameters affecting the process of changing levels. Slowly Findings and results of the study are mentioned below:

The most significant decrease in the estimated area was for the water areas that covered the same area occupied by the Gorgan gulf. The most significant increase in area is estimated for the wasteland land use, with other Land uses between the two ends.

The highest conversion level between the two uses is allocated to converting pasture use to wasteland and fallow lands and converting wasteland use to coastal lands. In terms of land stability or immutability, it has been the highest amount of stability in the water area, which is due to the large area covered by this land use compared to other lands, so that despite the reduction of 1,500 km of water levels over three decades. , The areas safe from its change have been more than the unchanged areas of other lands.

All the changes have been towards creating other uses in the water areas, reflecting the decrease of 150 square kilometers of the Gorgan gulf area in the studied period. Suppose the net changes from other uses to the idle user are estimated. The most significant increase in area was water levels to create coastal lands, while rangelands applied the most significant increase in the wasteland and fallow lands.

In terms of quality, changes in land use are divided into two categories: first, Gorgan gulf water zone uses, agricultural and garden lands and pasture lands that have suffered a reduction in area, and the second category, changes in the wasteland and fallow lands, coastal And is a built-in application that has shown a net increase in area.

One of the essential practical findings of modeling land-use change in the matrix is the probability of conversion between Land uses in pairs. In this study, the matrix is calculated based on changes estimated over 25 years and estimated for 2030. The values of the conversion rate matrix methods indicate that as the current situation continues, the trend of backwardness of the Gorgan gulf area will continue. What this study has clarified to some extent is that we have faced only the backwardness of the Gorgan gulf so that there is the slightest chance of returning from other uses to water areas. Also, the highest rates are estimated for adjustment to the wasteland user.

Funding :This research did not receive any specific grant from funding agencies in the public, commercial, ornot-for-profit sectors

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