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Studying the location of border tensions caused by climatic fluctuations in the Persian Gulf

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Abstract

The melting of the polar ice caps in the north and Antarctica and the increase in the water volume of the oceans and seas cause changes in the sea coasts, which lead to the reduction of the land area of the coastal countries and the submergence of some islands. This change in closed and semi-closed seas, where the coasts of opposite countries are located at a short distance from each other, will have legal and political consequences, which will be the source of conflicts and tensions between coastal areas. One of the beaches on the northern edge of the Persian Gulf, which is considered the normal baseline, is the distance between Bandar Jask and Bandar Abbas. An area whose baseline will be challenged by rising seas and will have legal issues in the future.

This article seeks to answer the question of how the rising water level in the Persian Gulf will affect the border issues between Iran and its maritime neighbors. The purpose of this research is to study the location of border tensions caused by climatic fluctuations in the Persian Gulf and the method of library and documentary research, and based on the statistics extracted from the sources, a new map was presented in the GIS environment with the techniques of this software. The results of the research indicate that the rise of the water level resulting from the melting of the polar ice caps in the future will cause a part of the land of the Islamic Republic of Iran to be submerged in front of Oman, and as

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a result, it will provide the basis for possible conflicts between Iran and that country.

Keywords: climate, climate change, territorial dispute, Persian Gulf, Bandar Abbas.

1. **Introduction and problem statement**:

The melting of the polar ice caps in the north and south poles and the increase in the water volume of the oceans and seas cause changes in the sea coasts, which lead to the reduction of the land area of the coastal countries and the submergence of some islands. This change in closed and semi-closed seas where the coasts of opposite countries are located at a short distance from each other and the basis of demarcation between them is the lines of origin and especially the normal lines of origin will have legal and political consequences that will be the source of conflicts between them.

In the semi-closed sea of the Persian Gulf, which is in the borders between countries, where the normal line of origin has been used due to the innocuousness of the coast; the rise of the sea level and the development of the land in the coastal areas can lead to problems for these countries in the future.

The region that has had the most important geopolitical and geostrategic positions from the point of view of different countries is the Persian Gulf region. The concentration of oil-rich countries, reliance on foreign powers, geopolitical proximity to Pakistan and Afghanistan, and major differences in the political-economic structure of the Persian Gulf are distinctive features of this region compared to other regions of the Middle East (Mojtahedzadeh, 2000: 334).

Since the origin of the territorial dispute is the lack of agreement between two or more countries on the ownership and control of a land; Unresolved such disputes may lead to conflict, conflict and even war between the governments claiming ownership of a certain territory. This issue is aggravated when the disputed territory is strategically important (Darami, 2006: 5).

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aggravated when the disputed territory is strategically important (Darami, 2006: 5).

The main axis of the Persian Gulf is also one of the tectonic consequences of the Zagros folding event, which was formed during the Plio-Pleistocene (Kraig, 2004: 4). The Persian Gulf region is a result of land retreat and sea water advance, that is, as much as expected from the effects of climate change in the increase of sea water level, the same amount of water itself is advancing and increasing the level. The rate of land retreat from the beginning of the 20th century to 2000 is estimated at 20 cm, and the increase in sea level for the Persian Gulf is twice the global average (UNEP Regional Seas Reports, 1994: 57).

Future research on climate change and its impact on the water level of open seas and possible border tensions caused by it (case study of Bandar Jask to Bandar Abbas) is the main concern of the authors in choosing this topic; which in turn is a new topic and has been done for the first time in the country in this research. Therefore, the central problem and question of the research that this research tries to address is, what is the effect of climate fluctuations on the water level of the Persian Gulf and possible border tensions resulting from it in the study area of Bandar Jask to Bandar Abbas?

Considering the applicability of researchers' research and field studies, library and document research methods have been used to obtain the rate of water rise in the past 50 years. In addition, GIS software has been used to analyze the data and provide a new map with a future research perspective.

Theoretical Foundations:

Natural geography of the Persian Gulf

Climate shows the general state of the air in a region and is subject to less change. In fact, climate is both a transforming factor and a phenomenon undergoing transformation. Climate changes appear both in the form of short-term fluctuations and long-term changes (Asagare, 2007: 28-30). Studies show that the world temperature has increased by 0.6 degrees Celsius after the 20th century (Bidhandi and others, 2008:2-3).

The Persian Gulf is considered as a semi-enclosed sea, because it is a gulf, surrounded by the countries of Iran, Iraq, Kuwait, Saudi Arabia, Bahrain, Qatar, the United Arab Emirates and Oman, and the Strait of Hormuz, which is the narrow opening of the gulf. The territorial sea of two countries Iran and Oman passes (pishgahifard, 2020:33).

The Persian Gulf is connected to the Oman Sea and the Indian Ocean through the Strait of Hormuz, which is located on the way of all sea lines in the east of Aden, like a corridor located between 24 minutes 30 degrees north latitude and 48 minutes 50 degrees east longitude. Its boundaries are limited to the coasts of Iran from the north and northeast, from the east to the Oman Sea, from the south and west to the Arabian Peninsula. The shallow waters of the Persian Gulf and under its bed have abundant oil and gas (hydrocarbon) resources. This depth at the mouth of the bay is 70 to 90 meters and it decreases as it goes towards the top of the bay and reaches 30 meters at a distance of 90 kilometers to the mouth of Shat. In most cases, the depth of the Persian Gulf does not exceed 50 meters, and its maximum depth reaches about one hundred meters (Noori, 2010: 129).

The countries bordering the Persian Gulf include Iran, Iraq, Kuwait, Bahrain, Saudi Arabia, Qatar, the United Arab Emirates, and Oman, and among them, most of the coast of the Persian Gulf, which is also navigable, is under the rule of the Islamic Republic of Iran. Even now, the Persian Gulf is the most important international waterway in the world, where more than 50% of the world's energy lies in it (Visi, 2010: 22).

From the geological point of view, the Persian Gulf is a shallow tectonic subsidence that was formed in the southern margin of the Zagros Mountains during the Tertiary period (Aghanabati, 2017: 41). The morphology of the Persian Gulf was formed by Plio-Pleistocene tectonics and Quaternary erosion and sedimentation (Kassler, 1973: 11).

The most intense folds of the Pliopleistocene time have folded the northern coasts of the Persian Gulf. The amount of folds continues towards the sea with less slopes and reaches 10 to 20 degrees in the sea (Shahrabi, 2010: 19-20).

The main axis of the Persian Gulf is also one of the tectonic consequences of the Zagros folding event, which was formed during the

Pliopleistocene. At the end of the Pliocene, the sea level was about 150 meters higher than the current level (Uchupi et al, 1996: 237).

Currents in the Persian Gulf mainly have three sources: density, wind, and tide. But the main and most important water flow in the Persian Gulf is anti-clockwise, which is caused by the difference in water density. However, the range of tidal currents in the Persian Gulf is large and exceeds 1 meter in all places. The importance of these currents is in the vertical mixing and mixing of water with a range of about 10 kilometers, and they are not important in residual circulation (Hilton, 2006: 66).

Table number (1): Persian Gulf water balance

Water inlet or outlet	Outlet Quantity
800-350 cubic kilometers per year	Net evaporation in the Persian Gulf
133-35 cubic kilometers per year	Inlet of rivers
7250 cubic kilometers per year	Surface water flow from Strait of Hormuz
6620 cubic kilometers per year	The water outlet of the Persian Gulf from the Strait of Hormuz
8600 cubic kilometers per year	The total volume of water in the Persian Gulf

Source: (www. persiangulfstudy.com)

Therefore, the influential currents are:

1. Sea currents:

The influx of seasonal unstable waters from the Indian Ocean to the Persian Gulf causes the water level to rise. Fluctuations in water level during seasonal changes affect the beaches and change the level. When the wave reaches the shore, it causes the transfer of sediment grains from one point to another. Therefore, the presence of any kind of obstacle in the Persian Gulf causes the sediments to hit the obstacles during transport and be deposited there, as a result of which the flow lines change (Alessi, 1996: 80-82.(

The speed of the water flow has a great impact on the amount of sediment transfer, and over the years, the currents lift the sediments from their place and transfer them to another place. The construction of the

artificial islands of the UAE affects the natural cycle of tidal currents in different lengths and echelons, which causes the natural purity of the sea water. The pattern of sea currents on the coasts of Iran and the islands of Qeshm, Abu Musa, Big Tonb, Small Tonb, Siri and even to some extent the currents entering and exiting the Strait of Hormuz will change in the long term and cause serious changes in the ecosystem of the region and even the possibility of displacement of forests It will have haza and coastal and sea trees (Darwin, 1995: 12).

2. Wind:

The prevailing wind direction in the Persian Gulf is NW, and this direction is more intense in winter than in summer, so the Persian Gulf in winter is under more air pressure caused by these winds on the water surface, and this factor affects the water level. The construction of these islands has also seriously affected the wind generated current and its pattern should be discussed and investigated by mathematical models (Darwin, 1995: 12).

3. Density:

In winter, in the far north of the Persian Gulf, water has a higher density than in the southern and western parts of this gulf. Along the southern and western coastline of the Persian Gulf, due to the more temperate climate during winter, due to high evaporation, the water has a higher salinity and this salinity level it is considered as one of the controlling factors of sediment transfer. Creating a barrier by building artificial islands in the Persian Gulf can affect the water cycle and even cause changes in the pattern of density currents (Darwin, 1999: 58).

Persian Gulf	temperature		salinity		density	
	Standard	Average	Standard	Average	Standard	Average
Jan-Feb	7.22	2.1	8.36	2.0	4.25	5.0
Mar- Apr	5.23	8.0	7.36	1.0	1.25	2.0
May- Jun	6.27	1.1	8.36	2.0	9.23	3.0
Jul –Aug	0.32	7.0	2.37	3.0	7.22	4.0

Table number 2 of the average and standard values of density, salinity and temperature in the Persian Gulf, Source: (Emery, 1956: 55)

Since the coast is a living organism, any change and construction on the coast should be carefully studied and their destructive, sedimentation, erosion and environmental effects (Salty Coasts) should be made, its effects on the morphology of the coast will be very serious.

Seasonal averages of the water level of the Persian Gulf in 1994:

In spring, the changes in the water level in the area are very small and imperceptible. In the summer of 1994, the average water level changes on the southern shores of the Persian Gulf, in the south of Bahrain and Qatar, are more than other places and around -5 to -17. In the autumn season, the average changes in the water level in different areas are insignificant and only in the southeast area, this value is around 8 to 10 cm.

In winter, the water level in the region is almost calm, and only in the southern areas of Bahrain and Qatar in the Persian Gulf, as well as in the vicinity of Chabahar and the eastern region of Sur in the northern Arabian Sea, turbulence is observed at the level of +-15 cm.

The annual average of water level changes in different regions of the Persian Gulf, Oman Sea and North Arabian Sea is almost zero. Based on this, only in the southern parts of the Persian Gulf, in the southern region of Bahrain and Qatar, and sometimes in the central and northern regions of the Persian Gulf, on the shores of Bushehr, the mouth of the Arvand and Karun rivers, and around Abadan, and in the central regions of the northern region of the Arabian Sea, in the east of Muscat and Sur. And in the sea of Oman around Chabahar, water level changes are observed effectively, and in other parts, the water level changes are almost zero and equal to the average water level in the oceans.

Monthly averages of water level changes in 1994. On average, in the month of January, the amount of water level changes on the shores of Bushehr is about 20 cm in the south of Bahrain, around the geographical area of 62 degrees east and 23 degrees north, in the Arabian Sea, about 28-

30 cm and in the southern region. The eastern diameter is about 45 cm lower than the base level.

In most of Iran's coasts, especially in the Strait of Hormuz, the monthly average changes in water level are always less than 15 cm, and only sometimes in Chabahar, Bushehr, Lange, Arvandroud mouth and around Abadan, the absolute diameter of these changes have been up to 20-30 cm.

The biggest changes observed in the Persian Gulf and the Sea of Oman during 1994 were +57.5 and +47. 5- Which are both related to the southeast of Qatar. The highest and lowest sea water levels were observed in the months of October and January, respectively, and the lowest changes in the water level were observed in the months of June and August (Arzem Sa, 1387: 83-96).

Geographical location of the studied area (Bandar Jask to Bandar Abbas):

This area around Bandarjask in the north of the Oman Sea and southeast of the Strait of Hormuz has a longitude of 56 degrees 47 minutes and 30 seconds east and a latitude of 26 degrees 25 minutes and 15 seconds north, and up to Bandar Abbas with a longitude of 56 degrees and 47 minutes and extends to 45 seconds east and latitude 26 degrees 35 minutes 15 seconds north and its direction is southeast, northwest; and it includes the cities of Bandar Jask, Bandar Sirik and Minab from the cities of Hormozgan province.

The geology of the region includes the western part of Makran zone. In terms of geological, stratigraphic and tectonic characteristics, this area is affected by the general characteristics of this tectonic unit, although in terms of topography, the coastal plain unit, which has a relatively smooth surface, is significantly different from the very uneven and complex elevations of Makran. This system, with a length of about 1600 km, consists of a series of almost regular troughs and troughs, whose axes are generally in the northwest, southeast, and west-east direction.

This line ends abruptly along the line known as the Ural Line, Oman Madagascar. This line was formerly known as the prison fault, which was

called "Minab fault" by the Berbers, the studied coast is the eastern bank of the Strait of Hormuz to its north (Yamani, 2017: 4-6). In terms of structure and geological features, the southern limit of Makran, as a morph tectonic unit, is the change line of elevations and the vast coastal plain of Oman, and its northern limit is covered by the Jazmurian crater. At the northern limit of that ophiolite, Cretaceous mélanges have appeared, which are separated from the Eocene flysch by the Beshagard fault.

In terms of the type of sediments, Makran highlands are mainly composed of Eocene, Oligocene flyschoid (flyschoid) layers, consisting of shale, marl and sandstone (Arazm, 2018: 44-45). Due to the low latitude, the prevailing air masses of the region are tropical almost all the days of the year. At the same time, the northern parts are alternately affected by polar air from Siberia to Scandinavia or the Mediterranean; In this case, the low latitude has its moderating effect. In the summers, this range is intermittently affected by the humid currents of the Indian Ocean, which affect the region from the south and southwest, and the effects of the summer rains caused by them can also be seen at higher latitudes. The average rainfall varied from 252.2 mm in Minab to 160 mm in Jask.

One of the most important climatic parameters is temperature. Its value in the heating network of regional stations varies from a maximum of 50 degrees in Minab at a height of 27 meters to a minimum of 2 degrees in Bandar Abbas at a height of 10 meters (Yamani, 2017: 85-90). Jasak station has an annual relative humidity fluctuation range of about 10% lower than other places, while Minab station shows the biggest difference with an annual fluctuation range of about 30%. Jasak and Bandar Abbas stations reveal the characteristics of coastal areas and Minab station reveals the characteristics of low-lying areas further from the coast. The studied area is drained from west to east by the important rivers Zarabi, Gaz, Jegin and small ponds respectively (Yamani, 2017: 101).

In the studied area, sea water movements are formed which are divided into three categories: waves, tides, and coastal currents; among the movements of sea water, waves play the most important role in the transformation of the coastline. In addition, it is considered the most active and continuous of them. In general, calm or slightly calm waves with a height of less than one meter prevail in more than 75% of the year in the

Sea of Oman and the Strait of Hormuz. However, waves higher than 1.5 meters average 5 to 6 percent of the time. The maximum period of their occurrence is spring and summer. In addition, the sea currents are stronger in the Strait of Hormuz compared to the Oman Sea and the Persian Gulf. The highest resulting wave was created at Jask station at about 4.5 meters (Yamani, 2017: 143).

Research findings:

Tides and tidal currents affecting the increase of water level:

The location and length of the coastline is not constant and it shows certain displacements in different directions on a daily basis, one in front of the sea water is in daily mode (H. w) and the other is behind it in tide mode (L. w). The study of tidal currents is important because the evolution of the coastline with changes in the water level provides different conditions for the performance of other sea water movements. For example, the power of the waves is distributed in a wider area by changing the water level. Therefore, in the comparison of two beaches, one with a low tidal range and the other with a high range, with the condition that the force from the wave is the same, there is more change on a beach with a shorter tidal range; because the wave force is distributed in a smaller area.

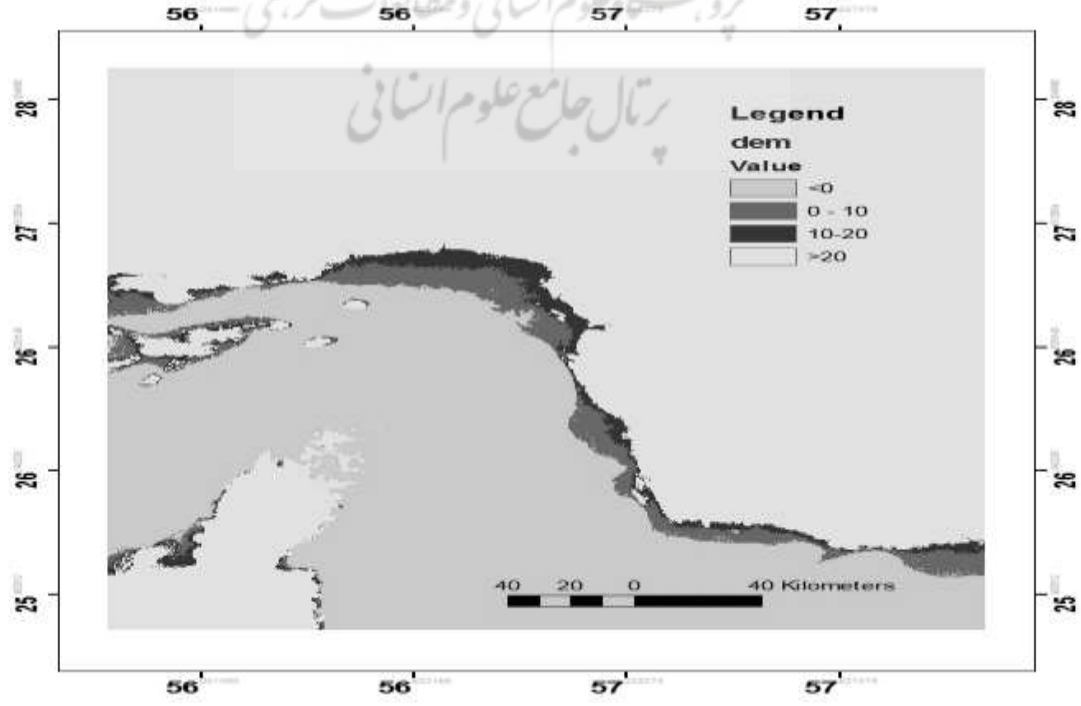
In addition, the amount of water advance from the mode depends on the slope of the topography of the bank. Because on a low-sloping beach, the amount of water advancing from the mode is much more than on a steep beach. Therefore, the diversity of geomorphological forms of the coastline is also a number of geomorphic and nological sub-environments of the coastline dependent on the function of tides and the resulting processes.

The statistics of Bandar Abbas, Bandar Shahid Rajaei and Bandar Jasek hydrographic stations have been used. Based on available statistics, water level changes are recorded every half hour. It means that water level changes have been measured 48 times per day. The mentioned statistics show that the range of Jezromed increases from Jask, Bandar Sirik stations to the north to Bandar Abbas, respectively. So that it's maximum range (M.H.W.S) reaches more than 4 meters in Bandar Abbas.

Table No. (3): The table of tidal levels along the coasts of the region (1989-1990)

Domain	L. L. W[4]	M. L. W[3]	M. H. W[2]	H. H. W[1]	ports
۴۳۷	-15	70	360	422	Bandar Abbas (Shahid Rajaei Wharf)
۳۹۳	-36	46	301	357	Sirik port
۳۲۸	-42	15	240	286	Jask port
۳۸۶	-۳۱	43	300	355	Average

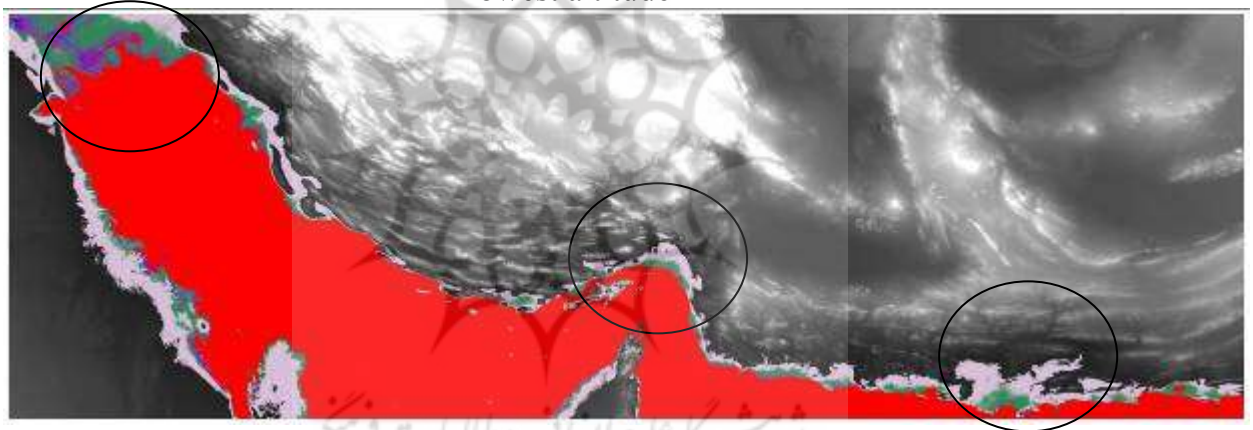
Map number (1): map of the elevation levels of the region



Source: research results (provided by the authors)

Considering that the "height" factor plays an important role in water penetration in the beach. Areas with a lower height are subject to more advance when the level of open water increases. The lower the "elevation" of the area, the higher the rate of water penetration and land loss when the water level rises. As can be seen in the map, there are more areas with a height of less than 5-10 and 100 meters on the Iranian coast of the Strait of Hormuz compared to the neighboring areas, and it indicates the tendency of these lands to go under water when the water level rises.

Map No. 2: Areas on the coasts of the Persian Gulf and Oman Sea that have the lowest altitude



Source: research results (provided by the authors)

As you can see, the above map shows the areas with the lowest elevation on the coasts of the Persian Gulf, which includes our study area and shows the progress of the water when the water level rises in this area.

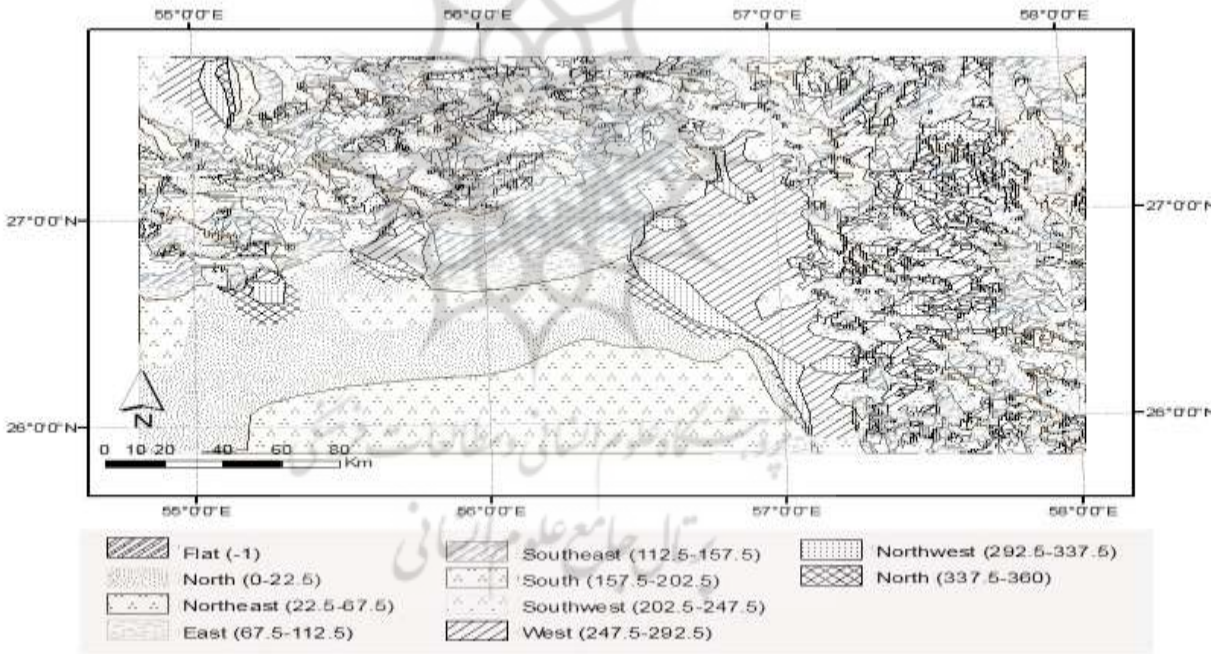
Table number (4): the area of the slope classes in square kilometers

Rowed	value	count	Area
0	2	10161	1016100
1	3	15117	1511700
2	4	5215	521500
3	5	7406	740600
4	6	7378	737800
5	7	7044	704400
6	8	9297	929700

Rowed	value	count	Area
7	9	4907	490700
8	10	2811	281100

Source: research results (provided by the authors)

Map number (3): Slope map of the area



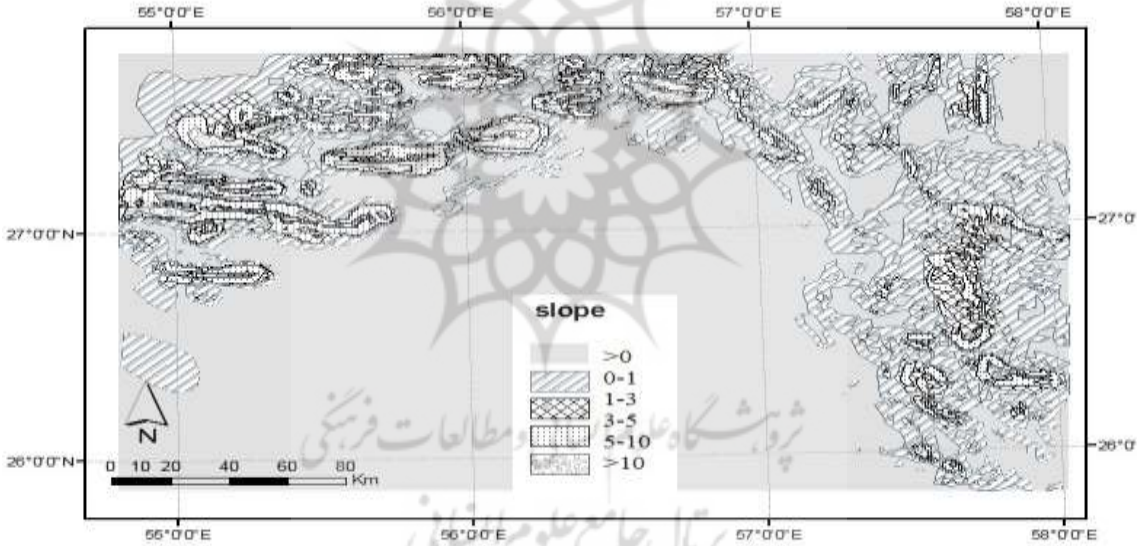
Source: research results (provided by the authors)

The "slope" factor is one of the most important factors in directing the flow of water. In the coastal area of the Strait of Hormuz, gentle and converging slopes are suitable for water flow. As shown on the map. In the Strait of Hormuz, the advance of 3% and 5% slopes widens inland, and it is steep and clear only in the current coastal boundary due to the action of

waves and the under-thrust of the oceanic crust under the coast of the coastal wall area.

The lower the "slope" of the area, when the water level rises, the amount of advance and penetration of water in the land and the loss of land will be greater. As can be seen, the slopes of less than 1 degree on the Iranian coast of the Strait of Hormuz are wider than the adjacent areas and indicate the tendency of these lands to go under water when the water advances.

Map number (4): Map of the slope directions of the area



Source: research results (provided by the authors)

Table number (5): slope area in square kilometers

Rowed	value	count	Area
0	0	44138	441380
1	1	14002	140020
2	3	5252	52520
3	5	4804	48040
4	10	1140	11400

Source: research results (provided by the authors)

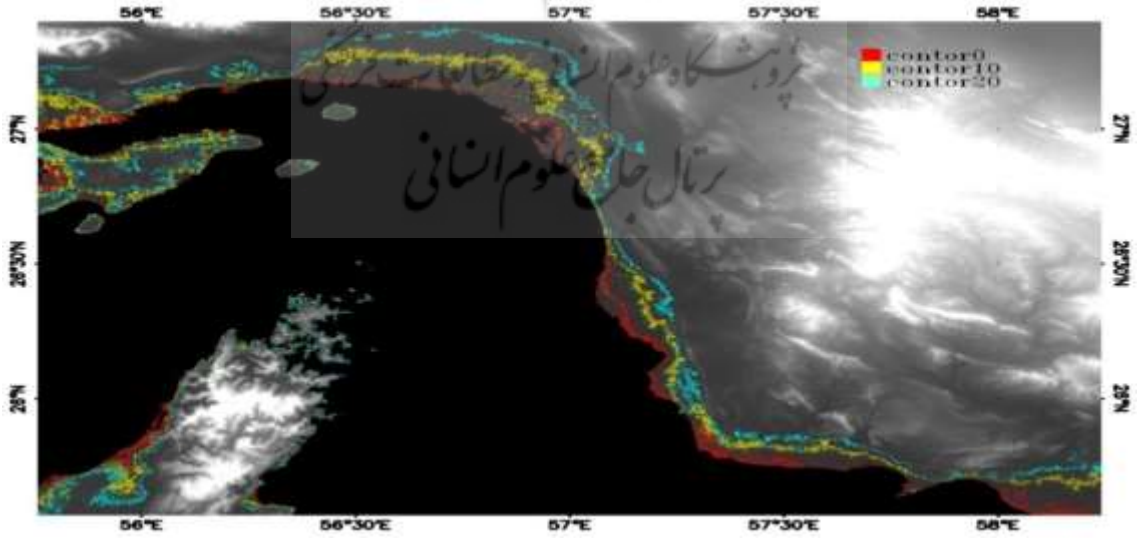
Fluctuations of sea water from 1870-2010:

Sea level fluctuations from 1870 to 2010 have been estimated by three reputable research institutes (CSIRO), which show that during this time period the sea level rose by about 14 mm. And because the Persian Gulf is also a semi-enclosed sea and has access to open waters through the Strait of Hormuz, this increase in water level also includes the Persian Gulf and is a reliable source that can be cited in this regard.

In order to obtain fluctuations and rise of water based on centimeters, the conversion unit of inches to centimeters was used, which based on the conversion, the amount of water rise in the Persian Gulf is 0.14 cm. Now, if we want to consider this rise of water in a period of 1000 years, the rise of water will be 140 cm. 1000 * 0.14 = 140 (Map No. 5)

Also, according to the same calculations, the rate of rise in the next 10,000 years will be 15 meters. Therefore, according to this process, it will take 14,000 years for the water level in the Persian Gulf to reach 20 meters (www.cmar.csiro.au).

Map number 5: The rise of sea water in 1000 years



In areas that have a lower height and upward slope, when the water level increases, we will be exposed to the advance of water and thus the possibility of losing the land. Due to the fact that the slope in the studied area, from BandarJask to Bandar Abbas, is one thousandth of a percent, so the amount of water advance in this area will be higher than in other parts of the Persian Gulf. Also, if the water level in the Persian Gulf rises, we will see the retreat of the water towards the coast, thereby changing the origin line. According to the chart of sea level fluctuations (Chart 1) which is related to the years 1870-2010, it can be concluded that the water level has increased by 14 mm (0.14 cm) in this time period.

Based on this water level change, we will have 140 cm in the next 1,000 years, 15 meters in the next 10,000 years, and 20 meters in the next 14,000 years. Due to the conditions of the lowest points of the tide, it has also risen from its current level and all the coastal cities and power plants in the target area, including Bandar Jask, Bandar Sirik, Bandzark, Deh Baz City, Minab City, and a large part of Bandar Abbas and Bandar Khamer have gone under water. And the Islamic Republic of Iran will lose a large part of its land, and all these reasons will change the starting line to determine the width of the territorial sea.

That is, at the end of this change and climatic developments, Iran's origin line will retreat towards the coast and will add to Iran's open waters. Therefore, in a future study of the region, it can be said that the future developments due to water level fluctuations in this region between Iran and Oman are due to the exploitation of oil areas and the loss of Iran's areas of influence, which may turn into conflicts.

Conclusion:

The melting of the polar ice caps in the north and south poles and the increase in the water volume of the oceans and seas cause changes in the sea coasts, which lead to the reduction of the land area of the coastal countries and the submergence of some islands. This change in closed and semi-closed seas, where the coasts of opposite countries are located at a short distance from each other, will have legal and political consequences, which will be the source of conflicts between them. One of the beaches on the northern edge of the Persian Gulf, which is considered the normal

starting line, is the distance between Bandar Jask and Bandar Abbas. An area that will be challenged by rising sea levels and will have legal issues in the future.

According to the findings of the research, all the coastal cities and power plants in the target area of the research, including Bandar Jask, Bandar Sirik, Bandar Zark, Deh Baz city, Minab city, a large part of Bandar Abbas and Bandar Khamer have been submerged, and the Islamic Republic of Iran has lost most of its land will lose itself and all these reasons will change the origin line to determine the width of the territorial sea. That is, at the end of this change and climatic developments, Iran's origin line will retreat towards the coast and will add to Iran's open waters. Therefore, in a future study of the region, it can be said that the future developments are due to the fluctuations of the water level in this region between Iran and Oman over the exploitation of oil areas and the loss of Iran's influence areas, which may turn into conflicts.

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