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RESEARCH PAPER

# Analysis of Shoreline Change along the Coast of the Wadi Al Ma’awil Watershed, Oman, Using the Digital Shoreline Analysis System

Amna Al Ruheili*

# تحليل تغير الخط الساحلي على طول ساحل مستجمعات مياه وادي المعاول، عمان، باستخدام نظام تحليل الخط الساحلي الرقمي

أمنة الرحيلية*

**ABSTRACT.** In an arid climate, lack of water constitutes a challenge. One solution can be to use storage dams as a tool to facilitate groundwater recharge and provide water for various uses. However, dams cannot be constructed without affecting the environment of the coastal shoreline and its ecological habitats. This study investigated the structural changes (i.e. accretion or erosion) of the coastline along the Wadi Ma’awil watershed. The Wadi Ma’awil watershed was dammed in 1991, providing a 10M $m^3$ dam capacity. Satellite images were obtained for 1972, 1984, 1994, 2008, 2014, and 2018, and coastlines were digitized. For this research, we employed the Digital Shoreline Analysis System (DSAS) to calculate the rate of coastline movement and the changes arising from dam construction or anthropogenic changes to the beach. The results showed that from 1972 to 2018, the shoreline experienced erosion of up to -0.70 m/yr for 56% of the watershed coast. This loss could result in remarkable coastal change. This study can be used by urban planners as support for the importance of preserving natural resources and ecological habitats.

**KEYWORDS:** *Coastal erosion, Ma’ awil watershed, Dam, Accretion.*

**المستخلص:** يشكل نقص المياه في مناطق المناخ الجاف يشكل تحديًا كبيرا. وتعتبر سدود التخزين من أحدالحلول المستخدمة لتسهيل إعادة تغذية المياه الجوفية وتوفير المياه للاستخدامات المختلفة. ومع ذلك ، لا يمكن بناء السدود دون وجود تأثير على بيئة الشواطئ الساحلية ومواردها البيئية. استقصت هذه الدراسة التغيرات التي تتمثل في عمليات التراكم أو التعرية للخط الساحلي على طول مستجمعات المياه في وادي معاول. حيث تم بناء سد مستجمعات المياهالجوفية في وادي معاول في عام ١٩٩١ ، مما وفر ١٠ مليون متر مكعب من المياه كمخزون في السد. استخدمت هذه الدراسة عددا من صور الأقمار الصناعية للأعوام ١٩٧٢ و ١٩٨٤ و ١٩٩٤ و ٢٠٠٨ و ٢٠١٤ و ٢٠١٨ ، وتم رقمنة الخطوط الساحلية لمنطقة الدراسة. واستخدم هذا البحث تحليل الخط الساحلي الرقمي (DSAS) لحساب معدل حركة الخط الساحلي والتغيرات الناشئة عن بناء السدود أو التغييرات البشرية على الشاطئ. أظهرت النتائج أنه من عام ١٩٧٢ إلى عام ٢٠١٨ ، شهد الخط الساحلي تآكلًا يصل إلى –٠,٧٠ م / سنة لـ ٥٦ ٪ من ساحل مستجمعات المياه. حيث يمكن أن تؤدي هذه الخسارة التي نتجت من حجب وصول الرواسب الى تامناطق الساحلية إلى تغير في الخط الساحلي بشكل ملحوظ. و يمكن استخدام نتائج هذه الدراسة من قبل المخططين الحضريين كأداة تدعم التخطيط العمراني كصديق للبيئة و تعزيز الاهتمام و الحفاظ على الموارد الطبيعية والموارد البيئية.

**الكلمات المفتاحية:** تآكل الساحل , مستجمع وادي المعاول , السد , التراكم.

## Introduction

The coastal zones provide both environmental and economic assets for a country. Coastal regions are dynamic systems that undergo key changes because of natural and anthropogenic factors. To maintain a coastal zone, regular sediment input for the deltas is necessary because the sediment maintains the deltas’ surface elevation, thereby contributing to reduced salinization, erosion, and flooding. Failure to transport sediment to the coastal plains and deltas increases the vulnerabilities that arise from sediment starvation and the land sinking (Wang et al., 2018).

More than 95% of ocean sediments come from water streams (Syvitski, 2003). The sediments carried by the water streams lead to the formation of deltas and development of coastal zones (Rao et al., 2010). However, deltas can be threatened by the changes in land use in upstream catchments and reservoir construction. These developments can impact the fluvial sediment inputs downstream and result in sediment starvation (Dunn et al., 2018; Kondolf, Rubin and Minear, 2014). Bird (1985) reported that most of the beaches in the world (about 70%) experience erosion because construction of reservoirs and dams in rivers prevent 20% of the global sediment from reaching the coast (Syvitski et al., 2005; Li et al., 2018).

A study conducted by Syvitski et al. (2009) showed that in recent decades, construction of reservoirs has prevented 20 to 100% of the global sediment from reaching the deltas. Moreover, there has also been a huge fall in river sediment loads in about 50% of the world’s rivers and dams. This is probably an important factor that determines sediment fluctuations between land and ocean

Amna Al Ruheili*(✉) alruheli@squ.edu.om, Department of Plant Sciences, College of Agriculture and Marine Science, Sultan Qaboos University, Muscat, Oman.

(Li et al., 2018; Syvitski and Milliman, 2007). Sediment load plays an important role in assessing the quality of the environment, and it allows researchers to evaluate the level of potential impact on the ecosystem (Khanchoul et al., 2012). Sediment is known to play a very important role in maintaining and developing coastal habitats and their ecosystems, which include wetlands, lagoons, coral reefs, mangrove swamps, dunes, and sand barriers (Kotti et al., 2018).

The construction of large dams has increased scholars' debate about the environmental impact of such structures because such dams decrease the rates of sediment delivery downstream, indirectly enhancing coastal erosion and decreasing habitat heterogeneity (Chang and Chuang, 2018; Rao et al., 2010; Syvitski, 2003; Tealdi et al., 2011). According to a study by Vorosmarty et al. (1997), about 30 to 40% of the sediment that would have been taken to the areas along the coast through the river systems was retained by man-made structures. The changes downstream were obvious and clearly arose from the shift in sedimentation deposits, which affected the morphology of the fluvial system (Ma et al., 2012). In another example, the Mekong River delta shoreline showed acceleration in erosion that was related to human-induced modifications such as dam constructions (Besset et al., 2016; Li et al., 2017; Anthony et al., 2015; Van Manh et al., 2015). Since the construction of the Aswan Dam on the Nile, moreover, the coastal area lost 98% of its sediment input and showed an increased erosion that impacted its coastal ecosystem (Giosan et al., 2014; Kim and Sultan, 2002; Syvitski, 2003; Syvitski et al., 2009). Moreover, the construction of the Three Gorges Dam led to 65% of the sediment load in the Yangtze River being lost (Yang et al., 2014). In Tunisia, inspection carried out after the Mejerda Dam was built showed an alarming narrowing of waterbeds downstream from the dam (Zahar et al., 2008). Furthermore, the Amazon River basin showed environmental and ecological distress resulting from the dam construction upstream. This construction resulted in a lack of sedimentation input that changed the downstream area (Latrubesse et al., 2017).

Satellite images and GIS data are important because they give us early estimates of shoreline change. Both these sources give us a good database for digitizing shoreline positional information which helps researchers to calculate the rates of historical change at the selected sites. The statistics estimated the speed of shoreline change gave us a cumulative summary of the processes that had affected the coast (Dolan et al., 1991). Varying sets of data can be used to assess coastal changes. The importance of this data depends on the way in which it was obtained (Dolanetal., 1991; Polk and Eulie, 2018). This study used End Point Rates (EPR) and Net Shoreline Movement (NSM) to calculate the speed of change of the coastline (Thieler et al., 2012). The study objectives were: (i) to find the definitions of the accretion and erosion areas, and (ii) to evaluate the speed at which shoreline was changing.

# Materials and Methods

## Study Site

The research area is situated in Northern Oman in the Al Batinah region along the Oman Sea. The coastal plain is narrow in shape at the northwestern and southeastern ends, and widens in the middle to a breath of around 50 km (Hayes and Baird, 1993). The geology of Al Batinah coastal region is composed of a tectonically emplaced late Paleozoic and Mesozoic continental margin and Tethys deep sea sediments known as Samail Ophiolites (Robertson et al, 1990). The local winds rarely exceed 10 knots at 10 m height with upwelling appearing as short irregular events (Vic et al., 2015). The coast of Al Batinah is mesotidal and tide-dominated. It has low wave energy and a limited littoral drift of less than 100,000 $m^3$/year (Kwarteng et al., 2016). The coastal plain has alluvial fans that have undergone the process of sedimentation that varies from gravel, coarse sands to fine sands and silt near the coast (Al Hatrushi et al., 2014). As a result, the plains along the coast are known for their high fertility, and that has resulted in heavy urbanization including agriculture and fishing activities (Al-Hatrushi, 2013).

The coastal shore of the Wadi Ma'awil watershed is located south of the coastal town of Barka. This area has small periodic (tidal) currents and a stronger flow (more relevant for sediment transport) occurs during a-periodic events that last several days (Bruss et al, 2018). The watershed has many wadis that flowed directly into the coastal area before they were dammed. The mean tidal range is 3.65 meters (m) (ONHO, 2018). The amount of yearly discharge of the catchment is estimated at 21.1 $Mm^3$/yr (Wilson, n.d.). The Ma'awil dam was constructed in 1991 as a ground water recharge dam with a capacity of 10 $Mm^3$ (MRMWR, 2012) as shown in Figure 1. The study area coastline stretches for about 25 km and has a gentle foreshore slope that ranges between 0.6 and 0.7%.

## Study Approach

This study went through three phases. First, various satellite images from different years were obtained (see Table 1). Second, the band combination shortwave infrared: Near Infrared: Red was used to emphasize the difference between land and water, after which the coastline was digitized, followed by determination of shoreline rates of change.

## Historical Shoreline Analysis

The information on changing shoreline was based on satellite images (1972, 1984, 1994, 2008, 2014, 2018) spanning a period of 46 years (see Table 1). The images were obtained from the USGS Global Visualization Viewer (http://glovis.usgs.gov) with their multicolored bands with a resolution of 30m×30m for pixel size, except for

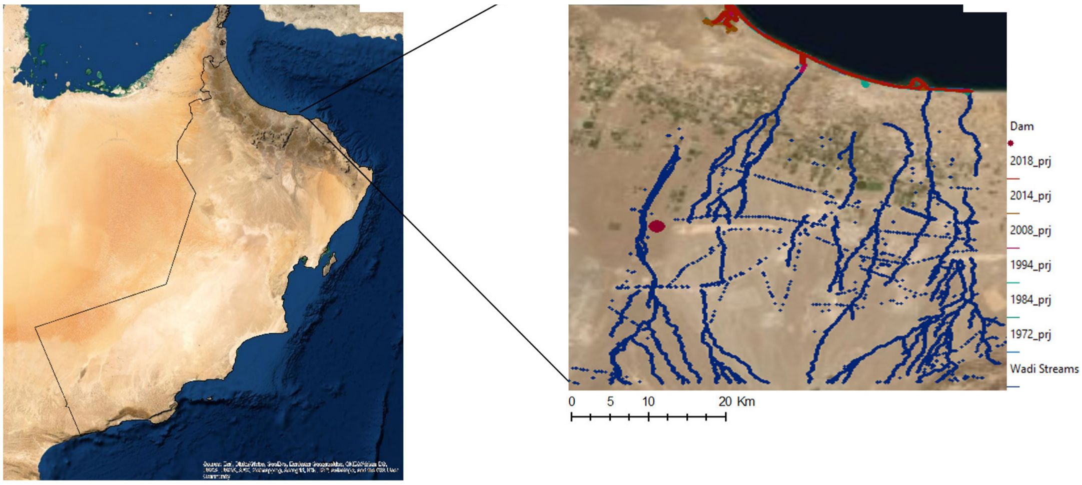

**Figure 1.** Study site, (a) Oman boundary, (b) Wadi channels of Al Ma'awil Watershed.

Sentinel at 15×15m pixel size. All the image data used were geometrically corrected based on the Universal Transverse Mercator (UTM) projection system—zone 40N using ArcGIS software 10.5.1 to attain less than 20 m accuracy of absolute planimetric (Fossi-Fotsi et al., 2019). There are numerous possible errors involved in deriving shoreline data and such errors can affect the accuracy of the computed rates in the modeling. Many studies have come up with estimates of the typical measurement errors that can happen during using mapping methods and shoreline digitization (Anders and Byrnes, 1991; Moore, 2000; Mortonetal., 2004). Shoreline extraction requires geo-referencing maps and subsequently interpreting and digitizing a shoreline position. This study Implemented Fossi-Fotsi et al. (2019) approach in measuring the uncertainty in coastal extraction with some modifications to calculate the annualized error (Table 2). The band combination of Infrared: Near Infrared: Red is used to best display the contrast between land and water boundaries to identify the shoreline in satellite images. The band combinations were done in ArcGIS 10.5.1. The purpose of using the band combination was to optimize the difference between land and water to facilitate digitization. The shorelines were manually and visually checked and reviewed to reduce errors.

## Digital Shoreline Analysis System (DSAS)

For the purpose of this study, we used the Digital Shoreline Analysis System (DSAS) Version 4.4, developed by the United States Geological Survey (USGS), to evaluate the speed of shoreline changes. The DSAS can be added as extension to ArcGIS 10.5 software. The DSAS can compute the rate of change statistically from multiple historical shoreline positions. The DSAS multiple statistical approaches, including the End Point Rate (EPR), Net Shoreline Movement (NSM), and Linear Regression Rate (LRR), were all used to calculate the shoreline change (Thieler et al., 2012). The LRR was used to measure rate of shoreline change because it is widely believed that it is the most statistically robust quantitative method while dealing with a limited number of shorelines (Addo et al., 2008).

After the completing the digitization of the coastline of the Wadi Al Ma'awil watershed, the DSAS was used to calculate the speed of coastline change and erosion. The analytical process involved four steps: (i) shoreline preparation represented by vectors data extracted from satellite images; (ii) baseline creation, onshore or offshore; (iii) transect generation; and (iv) computation of the speed of shoreline change (Thieler et al., 2012).

The software gave us transects along the shoreline which were cast perpendicular to the baseline with spe-

**Table 1.** List of Used Satellite Images

| Satellite | Year | Path/Row |
|---|---|---|
| Landsat 1-5 MSS | October 22, 1972 | 170/44 |
| Landsat 4-5 TM | October 8, 1984 | 158/44 |
| Landsat 4-5 TM | October 20, 1994 | 158/44 |
| Landsat 5 TM | November 11, 2008 | 158/44 |
| Landsat 8 OLI TIRS | October 11, 2014 | 158/44 |
| Sentinel-2A | October 23, 2018 | Tile #: T40QEM |

**Table 2.** Shorelines estimated and annualized error

| Variables | 1972 | 1984,1994 | 2008,2014,2018 |
|---|---|---|---|
| Digitizing error |  | 15.3 | 6.3 |
| Planimetric Error (EP) | 35 | 25 | 20 |
| Total error (Et) | 40.3 | 29.3 | 21 |

cific spacing measurements that are chosen by the user. After that, the points where the transect shoreline intersected with the baseline were used to calculate the speed of change statistics. During the course of this research we found that the DSAS program generated 3,816 transects with a 25 m spacing and 900 m length. These were perpendicular to the baseline located offshore at an 870 m length along the coast Figure 2.

### Rate of Shoreline Change

The End Point Rate (EPR), the Least Median of Squares (LMS), and the Net Shoreline Movement (NSM) were utilized to calculate the shoreline changes. The EPR measured through the distance division of the moved shoreline between the earliest and latest measurements at each transect by the elapsed time. The LMS was calculated by using the median value of the squared residuals instead of the mean in the LRR model to determine the best-fit equation for the line to all shoreline points for a specific transect. The NSM was associated with the dates of only two shorelines and it reported the distance between the oldest and youngest shorelines for each transect. The LRR was determined by fitting a least squares regression line to all the comparable shore points of different periods for a particular transect, using a confidence interval of 95.0% (Thieler et al., 2012). Positive values of EPR and LRR stand for sediment accretion through shoreline movement towards the sea, while negative values indicate erosion and shoreline movement towards the land.

## Results and Discussion

In coastal areas, the shoreline is very dynamic as it undergoes rapid changes. Waves and currents are the primary causes that lead to sediment re-suspension (Rajaee et al., 2009). The coastal areas provide a wide range of ecosystems that are critical to coastal resiliency and to economic development (Polk and Eulie, 2018). Both natural coastal processes and human interference are the main factors affecting shoreline change (Sheik, 2011). Frequent monitoring to detect shoreline changes is therefore important if we want to understand the processes and dynamic features of coastal areas.

The speed of change along the shoreline was calculated using the DSAS software and three different statistical techniques: End Point Rate (EPR), the Least Median of Squares (LMS), and the Linear Regression Rate-of-Change (LLR). The most significant changes were observed between 1972 and 1984, and between 2014 and 2018, when the shoreline was retreating at a rate of 1.6 m/year. The change between the period 1972 and 1984 could be attributed to the starting of development in Oman, and the country movement toward urbanization and modernity. While the period between 2014 and 2018 were subjected to various cyclones and storms events that could contributed to higher erosion. A summary of the statistics for the rate of change are given in Table 3.

About 600 transects were used to evaluate the rate of shoreline change along the coastline of the Wadi Al Ma'awil watershed for a short distance of 25 km. This has been shown in Figure 2. The EPR, LMS and LLR measured the rate of shoreline change based on differences between shoreline positions across time. The reported rates were expressed as meters of change along transects per year. The values of EPR and LLR for the research area from1972 to 2018 are presented in Figure 3.

The DSAS rate-of-change models for 1972–1984, 1994–2008 and 2014–2018 are represented in Figure 4. The

**Table 3.** Statistics for the Rate of Change

| Year | Variables | 1972–1984 | 1994–2008 | 2014–2018 |
|---|---|---|---|---|
| EPR | Mean mobility shoreline change (m/year) | -1.60 | 0.60 | - 0.66 |
|  | Erosion trend (m/yr) | -2.59 | -1.77 | -0.72 |
|  | & % | 73 % | 28 % | 93 % |
|  | Accretion trend (m/yr) | 1.24 | 1.52 | 0.20 |
|  | & % | 27 % | 72 % | 7 % |
|  | Total transects that record accretion | 183 | 478 | 68 |
|  | Total transects that record erosion | 490 | 86 | 594 |
|  | B. dist. from coastline (m) | 230 | 237 | 400 |

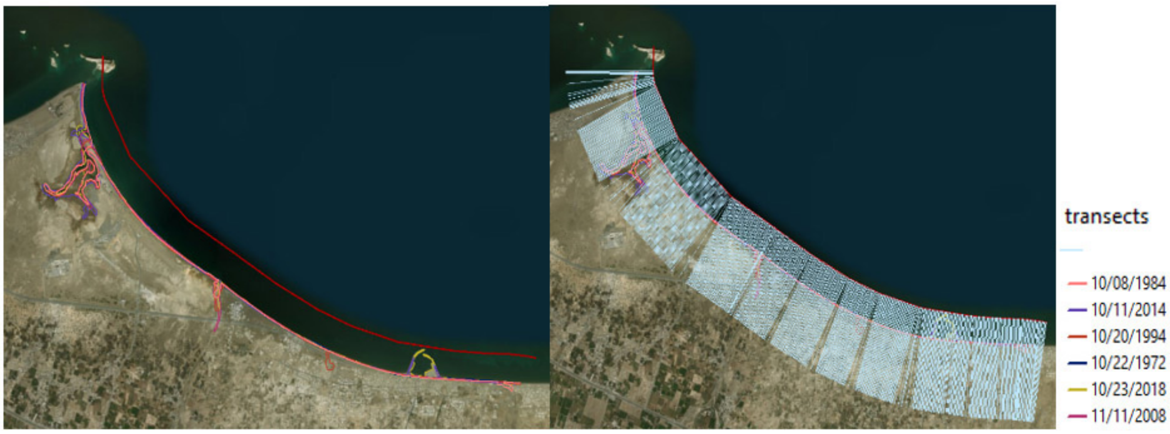

**Figure 2.** Shoreline of the study area.

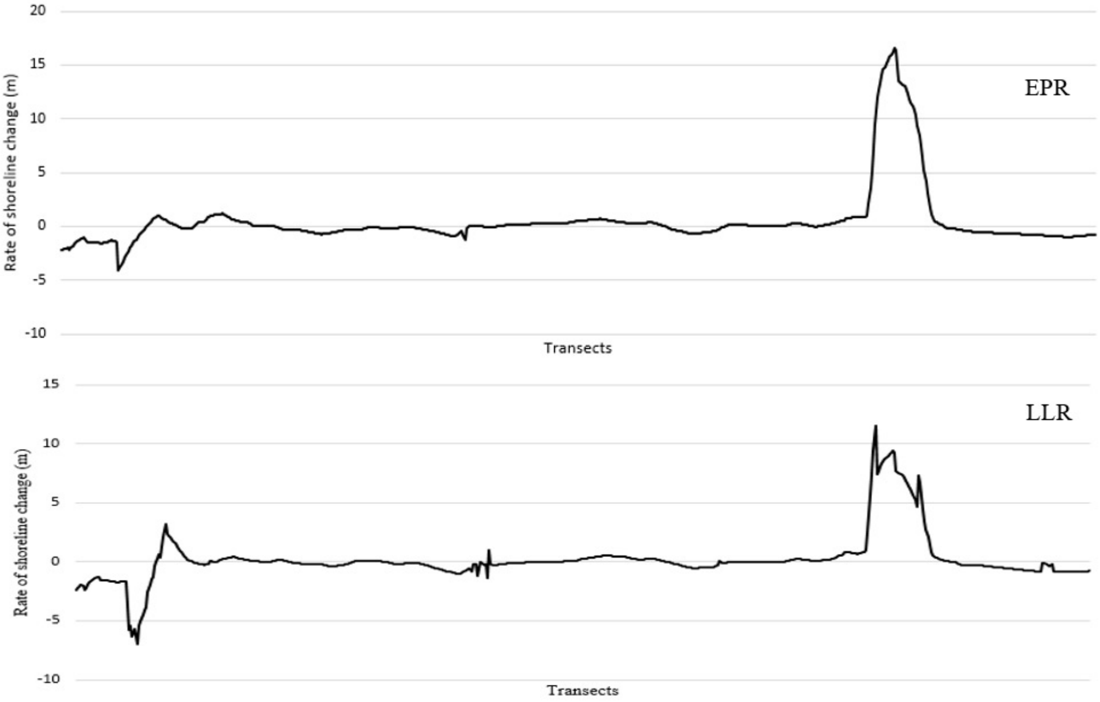

**Figure 3.** Variations in the rates of shoreline change (in meters) calculated using the DSAS program, alternating between erosion and accretion

EPR-Model and the LRR-Model show the shoreline point data that has the most confidence, with transects running perpendicular to the shoreline. It is clear that the positive and negative rates of change in Figure 4 show that both accretion and erosion are taking place on the coast. Table 2 gives us a summary of the speed of shoreline change as averages of all the changes, including both erosion (shown by the negative numbers) and accretion (shown by the positive numbers), and as averages of only the erosion values and only the accretion values. It would appear that some coastal area is being lost. This could be due to natural changes in the coastal system, or caused by human activities such as agriculture, irrigation and the building of dams. For example, dam construction could trap sediments in the upstream area in which obstruct the natural movement of sediments to the downstream area resulting in less nourishment for the coastal area (Al-Ismaily et al., 2013).

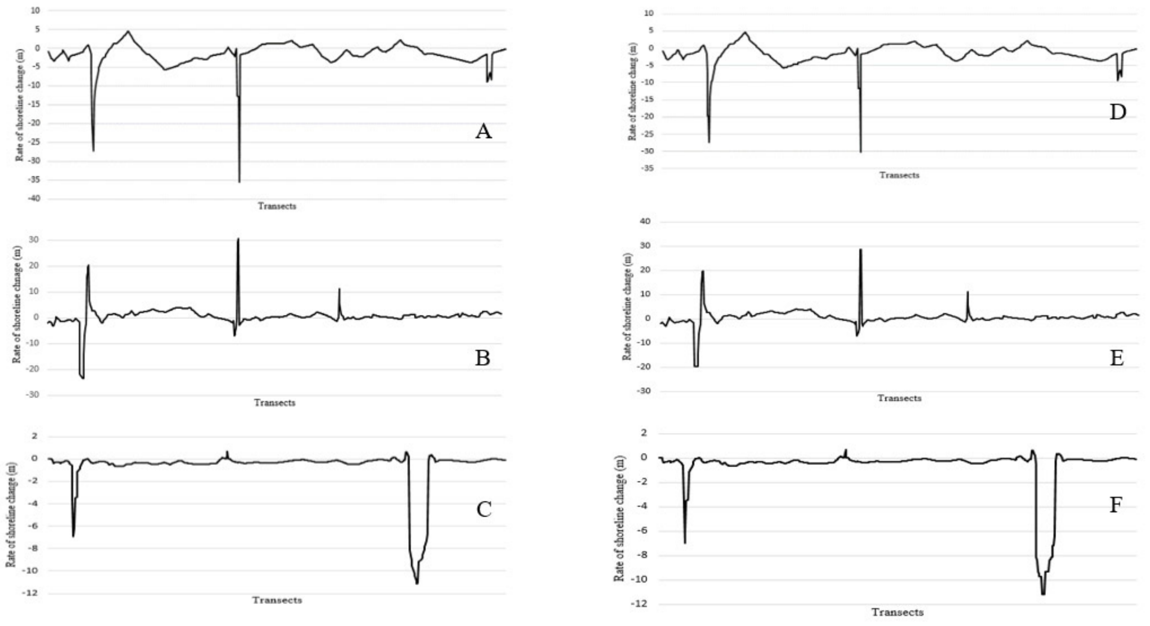

**Figure 4.** DSAS rate of change models in meters (A, B, C) EPR-Model; (D, E, F) LMS-Model for 1972–1984, 1994–2008 and 2014–2018, respectively.

The coast of the Wadi Al Ma'awil watershed was studied at various intervals in the years 1972-1984, 1994-2008, and 2014-2018. In 1972 through 1984, the net speed of erosion averaged over 490 transects was -2.59 m/yr. The accretion trend was around 1.24 m/yr for 183 transects. In the period 1994–2008, 86 transects accounted for an1.77m/yr erosion rate, and a 1.52 m/yr accretion rate was present for 478 transects. For 2014-2018, the coastal erosion rate was found to be -0.72 m/yr and the speed at which accretion was taking place was 0.20 m/yr. These smaller numbers could be related to the shorter period span. The movement of building recharge dams in Oman have contributed to shoreline changes. As stated by Al-Ismaily et al. (2013), dam construction in Al Khoud had limited coastal plains enrichment with silt and sediments that the wadies carry downstream to the valley. Other study carried by Graf (2006) indicated dam effect on river discharge, and sediment load that resulted in a quasi-equilibrium state of the river, altering the channel form. Therefore, the transposition of sediment and its redistribution play a major role in determining the geology, biology, and chemistry of fluvial ecosystems and coastal area. Overall, this research clearly showed that erosion and accretion have led to structural changes at the coastal shoreline of the Wadi Al Ma'awil watershed. The results also indicated that during 1972–1984 and 2014–2018, shoreline erosion increased. The highs and lows recorded are given in Table 3.

The shoreline experienced the greatest shoreline changes, with an NSM of 429 m, during the period 1994–2008. The sudden and rapid rate of shoreline change during this period may be due to beach nourishment activities and building of the port at Barka. Moreover, in 2007, a major cyclone hit the area and contributed to coastal accretion. In fact, all along Al Batinah coast the most severe erosion and sediment deposition occur during major storms events (Kwarteng et al., 2016).

Shoreline changes for the period between 1972 and 1984 were more variable, with most of the coastline being affected by erosion and only a few areas being stable. It was observed that between 1994 and 2008 the shoreline accreted in comparison with the period between 1972 and 1984, and also the period between 2014 and 2018 and this could be attributed to coastal nourishment activities. However, beach nourishment along Louisiana beach, USA, showed a temporal ability in serving as a beach barrier, but due to, wave and current action the shoreline retreated and the coastal vulnerability has increased (Cohen et al., 2021). The research area had an average EPR of -1.60 m/yr and an NSM average of -18.6 m between 1972 and 1984. However, the period of 2014–2018 also showed that erosion was taking place, with an EPR of -0.66 m/yr and an NSM average of -44 m, the coastal erosion could be attributed to cyclone Phet in 2010. For example, there are some studies indicated the impact of natural hazards and cyclone on beach erosion (Al Ruheili and Boluwade, 2021). This only happened for four years, and it is anticipated that the average EPR can increase with longer spans.

It should be noted that, during the coastal nourishment that related to coastal development, huge amounts of sediments were discharged along coast-

**Table 4.** Shoreline Highs and Lows at Wadi Al Ma'awil

| Variables | NSM (Max) | NSM (Min) | NSM (Avg) | EPR (Avg) |
|---|---|---|---|---|
| 1972–1984 | 54.53 | -400 | -18.6 | -1.60 |
| 1994–2008 | 429 | -332 | 8.3 | 0.60 |
| 2014–2018 | 46.65 | -749 | -44 | -0.66 |

al areas. The fast changes or the variations in shoreline change rate show that the dynamics of shoreline are being shaped by both natural processes and man-made activities along the Wadi Mawil shoreline.

## Conclusion

Many researchers have studied the consequences that the natural- and human-induced activities cause on shoreline change. Change can be the result of natural processes. Waves, currents, geology, variations in sea level, and storms can all contribute to shoreline changes (Zhu et al., 2018). In addition, human interference can also contribute to coastal erosion through by constructing dams, or urbanizing the beaches and thus changing the hydrological cycles (Bheeroo et al., 2016). Coastal geology also has a very important role in changing shorelines. The Wadi Mawil coastal area is marked by various coastal landforms, such as bays, beaches, and sand dunes. This study shows that the coastal area of Wadi Mawil is vulnerable to coastal erosion due to low-lying sandy beaches and dunes. The sediment transport depended on natural process and climatic factors that influence the nature of waves. The strength of these waves contributed to the amount of sediment transported, to erosion, and to accretion, all of which result in shoreline changes (Manjulavani et al, 2017). The sedimentation brought to the coastal area by wadis, rivers, tides, and winds through natural processes can be the most important factor in determining the shape of the coastline (Van Rijn, 1993). The amount of the sediment deposited on the coast determines its appearance, creating sand dunes and beaches, mangrove swamps, and mudflats (Storlazzi and Field, 2000).

Most studies, to date, have indicated that the growth of the coastal region is associated with sedimentary processes which contribute to the coastal geomorphology (Pranzini et al., 2013). For example, islands in the Indian Ocean have eroded due to a shortage of sediment on the shoreline (Mujabar and Chandrasekar, 2011). During the period from 1994-2008, north Oman experienced Cyclone Gonu (2007) and that resulted in accretion due to the abnormally high quantity of sediment discharged through the wadi and storm surge. However, now the coastal area is showing signs of erosion, due to a shortage of sediment that could be related to disruption of the natural process. Sediment discharges from wadis have been reduced due to various factors such as dam construction, coastal developmental and encroachments. This makes the rest of the sandy beaches in the area more susceptible to erosion. The changing shoreline is very important to efforts to calculate the spatial dynamics of the Wadi Al Ma'awil coastal system. The Al Ma'awil coastline is threatened by erosion that may contribute to ecological and economic loss along its coastal zone. Human factors, such as sand extraction from beaches, reclamation of land for agricultural use, and the damming of wadis, have modified the system flows and have contributed to coastal erosion. Reduced sediment supply caused by damming the Wadi flow has also led to more loss and damage of coastal habitats, including beaches and mangrove swamps. The sediment supply to the coastal area has been trapped by the dams that have been constructed. This research shows that the Wadi Mawil watershed is being eroded due to this impediment of the natural process and as a result of the modification of the hydrological processes that occurred in the study area after the dam was constructed in 1991. The Wadi Mawil coast now faces an additional, urbanization problem as new port and tourism developmental projects take place along the coast. Building artificial barriers increases erosion along the Wadi Mawil coast.

Accurate coastline identification conducted using Landsat and Sentinel satellite images is a useful approach given the moderate spatial resolution and good spectral resolution provided by these tools, which helped in defining the shoreline. Coastal accretion was most significant in the period 2008–2014, possibly because of the ports that were being constructed during that time. Coastal erosion was also dramatically apparent in some parts of the study area in 1972–1984 and 2014–2018. Erosion was observed at 73%, 28%, and 93% for 1972–1984, 1994–2008, and 2014–2018, respectively. The coastline is deteriorating at an average rate of -2.59 m/year, -1.77 m/year, and -0.72 m/year, respectively. The overall average of the EPR for the entire coast is accreting at the rate of 0.50 m/year. The research area has natural as well as economic importance for agriculture and drainage, but damming the wadi modified the watershed regime and contributed to coastal change. The DSAS shoreline change analysis showed that erosion was taking place in the area being studied. Natural processes as well as human interference have changed the shoreline of the study area through erosion and accretion. The coastal zones of the Wadi Mawil watershed, have accretion due to sediment deposition during the 2007 Cyclone Gonu storm surge and Wadi flash flooding. However, dams have stopped the transportation of sediments which in turn led to erosion in the coastal areas. This research clearly shows that proper beach filling and nourishment should be made along the coast to protect the coastal area from severe hazards. This can also help restore the area. It further explicates that local managers and decision-makers should take into consideration the impacts of dams on shoreline erosion. It is clear that such construction significantly contributes to changing the ecosystems and the habitats of the coastal zone. The study also documents that the DSAS can come up with important data which can help us in determining shoreline erosion and accretion.

## Conflict of Interest

This research has no conflict of interest.

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