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IMPACT OF SEA LEVEL RISE IN THE GULF OF SП)RA, LIBYA USING SRTM-DTM

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Emission of greenhouse gases, increased use of CFC etc are responsible of global warming, which leads to the sea level rise (SLR). According to (Nicholls and Hoozemans, 1995) allowing population growth further increases the vulnerability analysis indicates at least 400 million people would live beneath the 1 in 1000 years storm surge after a Im rise in SLR in the Mediterranean region. The study area lies in the north east Libya fronting the Gulf of Sidra and boarders with the Mediterranean Sea in the north. The study area is used for settlements, oil refinery, harbour and seasonal agriculture. It has a coastline of265 km and a population of 190397 (report 2005). The study area lying between 130 m above sea level and 37m below sea level. In methodology M, SRTM-DTM, has been used to analysis the impact of SLR and coastal change. Analysing SRTM-DTM model gives us a better picture of 1 % & 2 % increase of impact of SL in future due to higher resolution and accuracy of the image. Vulnerability in economic

sectors like the urban area and road, there is an increase of the impact in percentage more than those of the pipelines (drinking water and oil pipelines).

Introduction

The literature confirms that indirect effects of sea level rise, as well as the potential impact of extreme events, may be more significant than direct effects in the future. Lots of scenarios have been developed for many years by scientists who have warned us about the long-term impacts of ever-increasing emissions of greenhouse gas (especially the carbon dioxide emissions - CO_2). By the end of this century, our planet may look very different than it does now. There is concern that human activities may be inadvertently changing the climate of the globe through the enhanced greenhouse effect, if this occurs, consequently changes may have a significant impact on society. The issue is now central to the cunent environmental debate and is high on the political agenda of the most industrialized nations.

A study have been done by IPCC (1995), The Second Assessment Report estimated changes in the number of people flooded by storm surges due to a one meter sea-level. The rise in sea level assumed was just above the top end of the range for 2100. Three factors have been investigated that the changing happened simultaneously were: global sea-level rise, coastal population, and upgrading flood protection due to increasing national wealth. Global sea-level rise was estimated from the thermal expansion calculated in IPCC 1995; the total rise by the 2080 is predicted to be 44 cm and number of people at risk is approximately 10 million, rising to about 30 million in the 2080s under the reference scenario of constant (1990s) flood protection and no sea-level rise. Given the sea-level rise scenario, the number of people at risk increases dramatically being about 700 % above the reference scenario by the 2080s, Most of the people at risk in the 2080s are concentrated in a few regions, particularly the southern Mediterranean, Africa, southern Asia and South East Asia.

Stady area. The study area is located in the north East Libya. It is located in front of Gulf of Sidra and borders with the Mediterranean Sea in the north. It geographically lies between 30°00, 31°OO N and 18°00, 21°00 E. The study area occupies 24,042 sq km in total. It consists of 21,802 sq km land and 2,240 sq km Sabkha. The coastline is 268 km length.

The population in the study area is 190397 (report 2005). They use the area for settlements, oil refinery plant and harbour. Seasonal agriculture are found there and animal pastures (grassland) mainly camel and sheep. The area is also the location of the commercial service. The area is affected by sea level rise and there is a probability of flooding from the coast once it happens. Therefore, this area is taken as the study area, considering its commercial service's function and its effects from sea level rise.

Geologycal Structure of the area. According to Barrand Weegar (1972); Gumati and Kanes (1985); Baird et al (1996) The sirt basin rift phase, which established the distinctive configuration of the basin, began in the Cenomanian with the collapse of the Sint-Tibesti arch, basically, five major grabens formed (Hun, Zallah, Maradah, Ajdabiya, and hameimat), separated by for major platforms (Waddan, Zahrah, $Bayda_1$ Zaltan, and Amal-Jalu)

Figure 1. Study area location

The orientation of these structural features was generally north - north west to south - south east, a fabric which persisted through out the recurrent episodes of faulting during the late cretaceous and Palaeocene.

Materials and methods

The data which has been used in this study is SRTM data (Shuttle Radar Topography Mission-Medium resolution) with pixel size of 90 m. The data is downloaded from the web page: ftp://edcsgs9.cr.usgs.gov/pub/data/srtm/Africa.

Different softwares (ENVI, ERDAS, and ILWIS) were used for processing, analysing and calculating the effected area. It has been decided to model the sea level rise in three levels, where O meter have been taken as the present situation, 1 meter have been taken to enhance the sea level rise where is taken as a much worse than the present situation for the impace area. 2 meter is the worst case where this number is the same as the 1 meter rise but with strong wind storm makes it much higher which is comes to 34 nodes, Doxiadis (1980).

The most hazardous areas calculation for the enhanced sea level rise 0,| and 2 meter above the sea level has been made using the ILWIS calculation command of the following Map Calculation formula as fellows:

DEM Om = iff(inrange(DEM AJDABIYA,-77,0),0,l)

DEM 1 m = iff(inrange(DEM_ AJDABIY A,-77,1),0,1)

DEM2m = iff(inrange(DEM_AJDABIYA,-77,2),0,l)

After all, we calculated the area in pixels of the most vulnerable area.

Grid size in meter (2 decimals)	**8576. 5m²**

The vulnerable area for the area at present (0 meter) above the sea level

$$0,0085765 \cdot 261181 = 2240 \text{ km}^2$$

The same calculation has been done with 1 and 2 meter above the sea level.

The vulnerable area (Imeter) = 2477 km^2

The vulnerable area (2meter) = 2718 km^2, after that we calculate the impact of the 1 and 2 sea level rise.

Results and discussion

The analysis of SRTM-DTM is done based on the three sea level scenarios: present sea level scenarios, one meter sea level scenarios and two meter sea level scenario. The aim of this is to observe the areas that are impact to the rise of sea level and asses the effects. At the end, comparison will be made based on the three scenarios.

1- Impact of sea level rise of present sea level scenario. For the present sea level rise, areas that are impact are mainly of urban areas near by the sea. From the calculation, it can be seen that 2,240 km^2 of total area is impact to the present sea level, or 11 % of the total area is effect. In this situation, the area consists of 21,802 km^2 of land and the area is not affected by the present sea level. Therefore, the impact of the rise of sea level would be assessed in the next session. The present sea level scenario will be the basis for the comparison and as standard level for assessing the impact of sea level rise in the future.

2- Impact of sea level rise of 1-m sea level scenario. The I-meter sea level rise causes more areas are impact for this case. The areas impact is not only the urban areas and the areas nearby the sabkha but expanding to some low lying area. It is also affected by the topographical and geological condition of the areas.

From the calculation, it can be seen that 2,477 km^2 is vulnerable to the sea level rise. The effect of this is that there is a decrease number of total land area from normal sea level from 21,802 km^2 to 21,565 km^2. There is a 1 % of the land area that is affected by the sea level rise of 1 meter.

The impact of sea Level Rise (SLR) in future (%) for Im is calculated by following formula:

Impact of SLR in future =

= (Vulnerable area for Im SLR - Present vulnerable area)-100/Total study area.

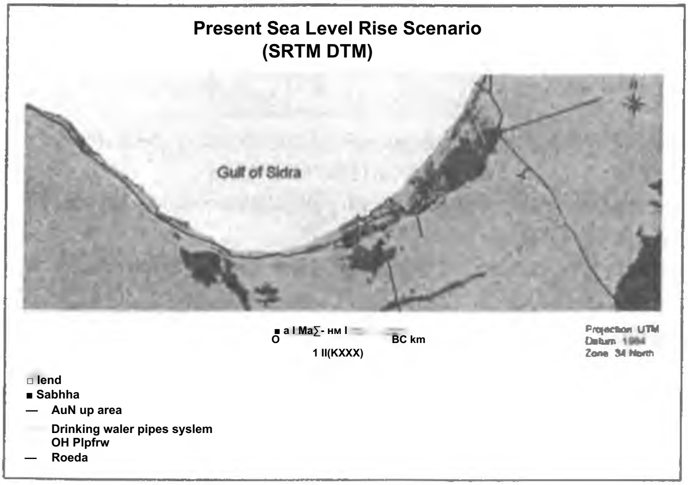

Figure 2. Present sea level rise scenario (SRTM-DTM)

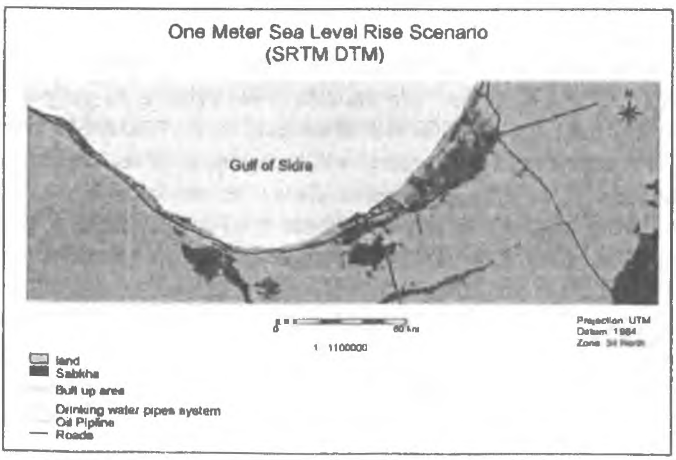

Figure 3. 1 meter sea level rise scenario (SRTM-DTM)

3- Impact of sea level rise of 2-m sea level scenario. There is a great increase of the area that can be affected by the sea level rise of 2 meter. 2,718 km^2 of the area is impact for this scenario. Total land area is more decreased than that of 1-m sea level scenario. There is a decrease from 21,324 km^2 area to 21,565 km^2 that is impact and 2 % of the land area is affected by this scenario.

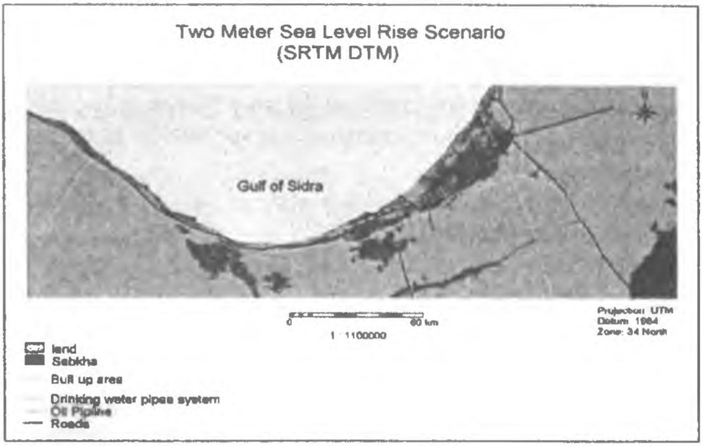

Figure 4. 2 meter sea level rise scenario (SRTM-DTM)

The impact of sea Level Rise (SLR) in future (%) for 2m is calculated by following formula:

Impact of SLR in future = (Vulnerable area for 2 m SLR - Present vulnerable area) × ×1 OOZTotal study area Comparison of impact ofpresent, 1-m and 2-m sea level rise scenario using SRTM-DTM.

The analysis using SRTM-DTM proves that the increase of sea level rise also affects more areas. This is indeed, the well-known matter-of-fact. There is no impact to the area at the present sea level condition. It means the society is safe from the impact. However, there is a linear correlation with the increase of the impact areas affected by the condition. The more rise, the more impact areas. Using SRTM-DTM, however, gives less difference of area affected by sea level rise. The number is less that that analysis using GLOBE DEM, though they both have proved that the sea level rise gives more impact to the areas.

The comparison of the present, 1 and 2-meter sea level scenario can be seen in the table below.

Table 1

Impact of vulnerability in future global (SRTM-DTM)

Sea Level Change	Land (km^2)	Vulnerable Area (km^2)	Impact of Sea Level Rise I in Future (%)
Present (Om)	21802	2240	–
1 meter	21565	2477	1
2 meter	21324	2718	2

Analysis of the impact to the economy

At the end, to see the real impact of the sea level rise on the area, a number of variables are included from geological map and satellite image are:

- Urban area;
- Road;
- Drinking water pipelines;
- Oil pipe lines.

Table 2

Impact of Sea Level Rise on Urban area, reads, and Drinking water and Oil pipelines

Sea Level Change	Urban Area Below Sca Level (km^2)	Urban Area (%)	Roads Area Below Sea Level (km^2)	Roads Area (%)	Drinking water pipes Below Sea Level (km^2)	Drinking water pipes system (In %)	Oil Pipeline Below Sea Level (km^2)	Oil Pipelines (%)
Present (0 m)	21	36	7	15	2	6	4	12
1 meter	24	42	9	20	2.5	8	4	12._
2 meter	28	49	10	22	3	10	5	30

T he assessment of these variables is done using SRTM-DTM. This is due to the more accuracy result of the analysis shown in the previous discussion. Several operations are done before having the result as shown in the table below:

The result shows the impact of the sea level rise of different scenarios. For the urban and road, there is an increase of the impact in percentage more than those of the pipelines (drinking water and oil pipelines). This is due to the old system of settling, where the people did not really take into account the topography and the possible effects of sea level rise. Sea level rise is a global issue right now that appear in the surface for the last decades. Therefore, when designing the urban area and its component, they did not take into consideration the present hot issue about sea level rise. This is strengthened by the fact the urban areas are old and it keeps expanding till now and the pipelines systems are carefully studied before being built.

Conclusions

SRTM - Data has been used for modelling the sea level rise phenomena. The results obtained show the affect of this phenomenon on the economic sectors like urban area and the infrastructure of the cities. The urban area and roads are more affect than the pipe lines because of their locations.

Recommendations

1. There is a continuous need for vulnerability assessment within the framework Ofimproving coastal zone management.
2. Due to sea level rise, areas will be salted and hence will become uncultivable. Such areas can be protected by contracting the defending walls. But the price rather high.
3. Future land use planning can be done looking towards the different scenarios of sea level rise for instance making highway, railroad, new built up area etc.

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THE USE OF REMOTE SENSING AND GIS TO STUDY THE LAND COVER OF AN AREA CLOSE TO THE CITY OF TRIPOLI LIBYA

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The GREAT Jamahiriya is located in North Africa along the Mediterranean sea. The study area is subtended by the sea at north and a latitude line of $32^0 4\theta'$ south and longitude line of $12^0 57.8,$ east and longitude line of $12^0 39^z$ west. This section is very important because it is mainly an agricultural area as well as it is full of forests and trees. The technologies of Remote Sensing and Geographic Information System (GIS) are both used to study the changes of replacing the agricultural area by the small farms and residential projects. In other words it is