

**Integrated remote sensing multi
concept and GIS for assessment of sand
dune distribution and impacts on Sinai
resources, Egypt**

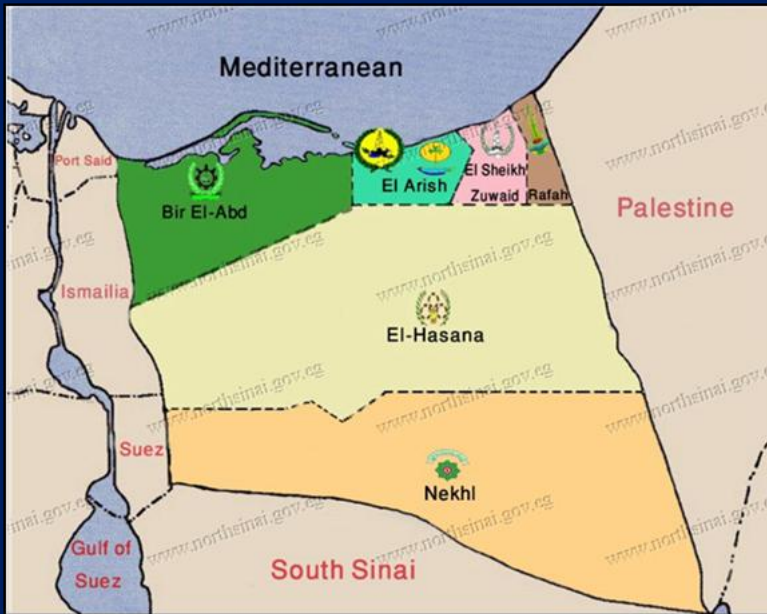
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National Authority for Remote Sensing and Space Science (NARSS)

Location of Study Area

Sinai peninsula is located north east of Egypt between longitudes 32.34 E and latitudes 29.31 N , and bounded to the north the Mediterranean Sea along the 220 km. The area of the province is about 27 thousand km² with estimated population of 352 thousand people in 2010.

It is characterized with two types of environments: The "coastal environment" on the Mediterranean and El Bardaweel Lake, in the North, and the "desert environment" in the mountains, valleys, and natural springs in the South.



Economic Importance of Sinai

Sinai Peninsula represents the deep rooted history as the eastern gate of Egypt.

It is the only part of Egyptian territory located in Asia, effectively serving as a land bridge with Africa.

Sinai with its tourism, mineral, industrial and agricultural resources, is a pillar of the ambitious strategy of Egypt to leave the crowded narrow Nile Delta and to expand to a larger area.

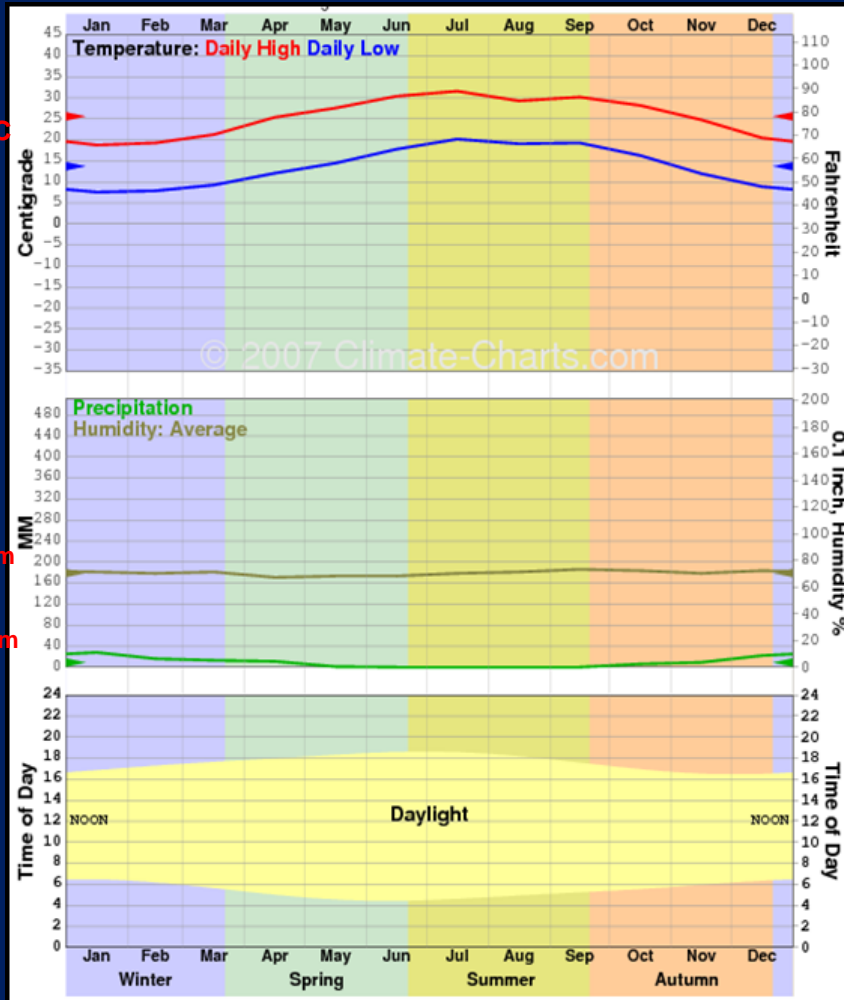
Moreover, Sinai is also part of the Suez Canal region where a number of Egyptian mega projects are initiated at the west of Suez Gulf. A new Suez Canal project is constructed to maximize benefit from the present Canal and its by-passes, and facilitate traffic in the two directions and minimize the waiting time for transiting ships.



BEFORE

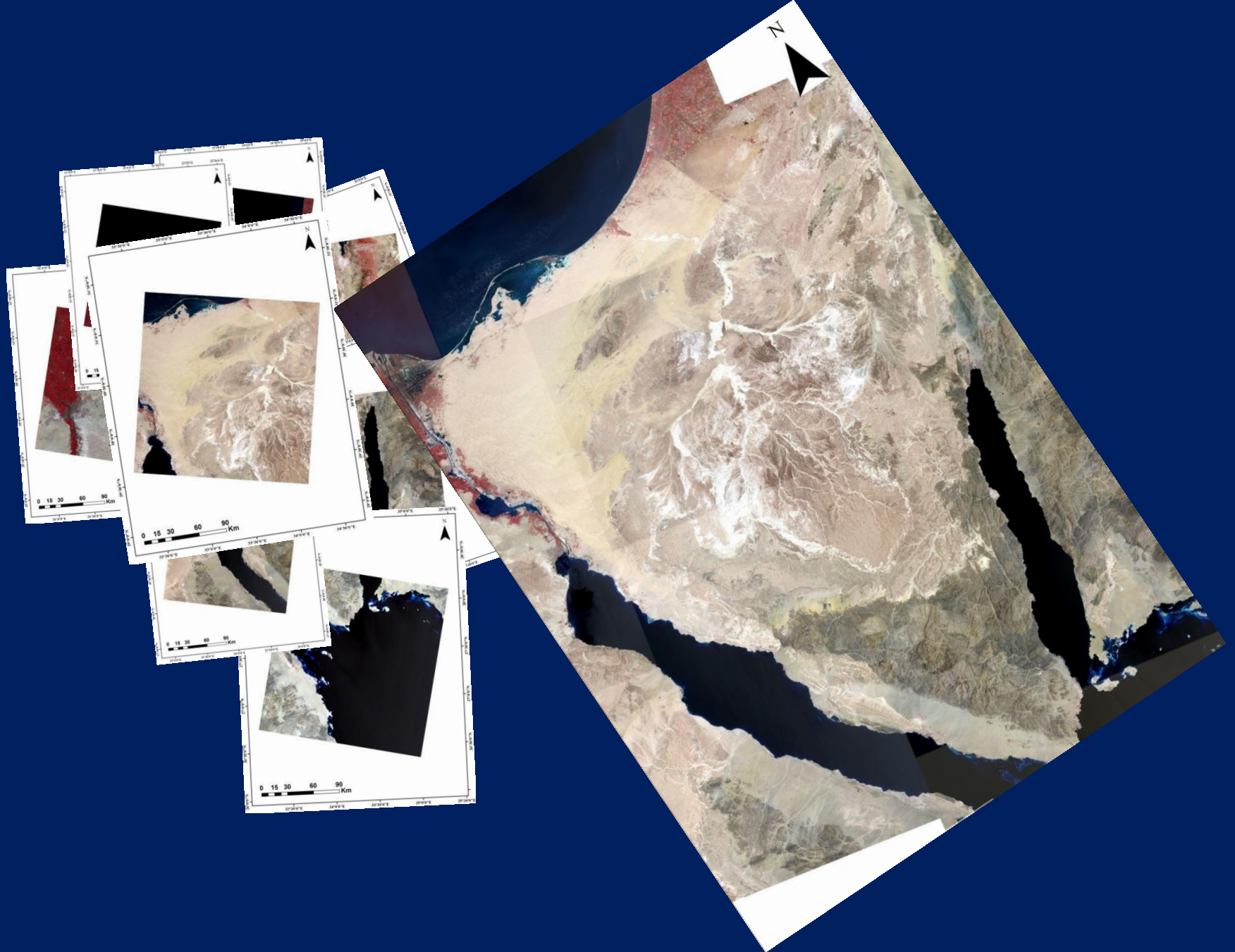
AFTER

Climate of Sinai



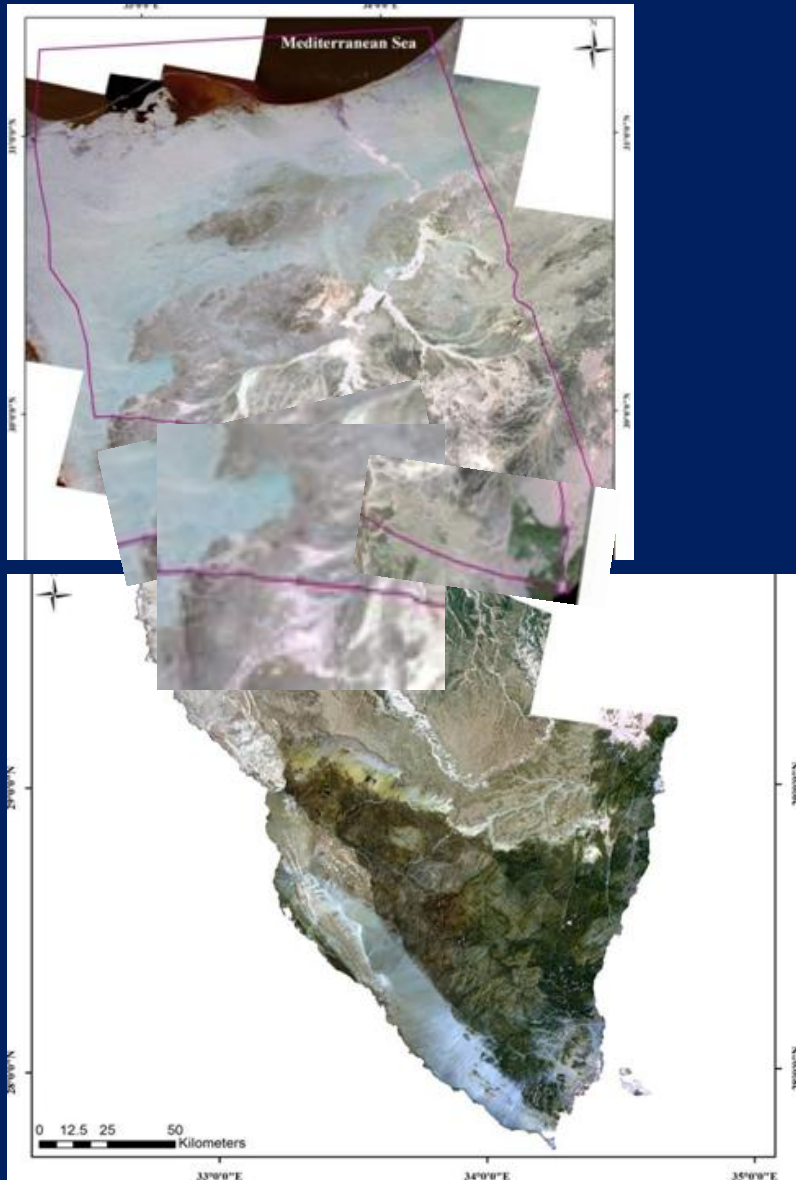
Climate Data of North Sinai

1. The Sinai climate is unique. it begins' in the north, by a Mediterranean climate then ranging to be up to the climate close to desert areas and semi-desert.
2. It is high temperature in summer and the warmth of winter, with temperatures ranging between 10 degrees winter to 24 in summer.
3. The rates of annual rainfall 28.0 mm, however reach 200-300 mm in north, down to 0 at south and west.
4. Opportunity for plant cover to grow is minimized.



SPOT mosaic of North and south Sinai

Satellite Images



A number of 8 SPOT satellite scenes, covering the whole territory of Sinai, imaged during the year 2015, were collected and processed to be included in the GIS land resources database.

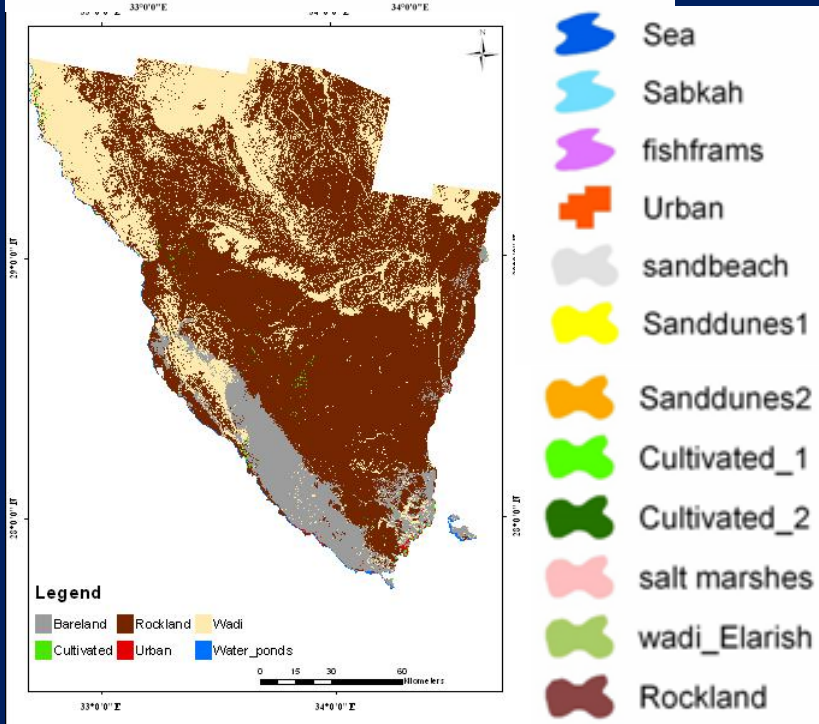
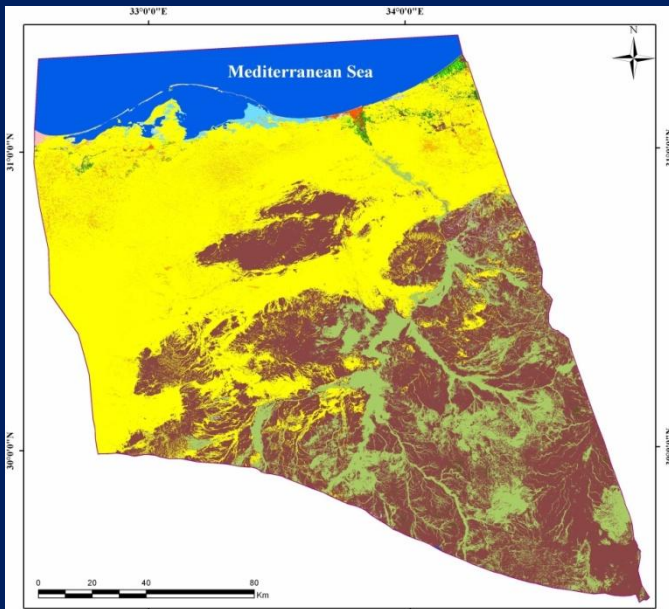
Image pre-processing was applied to enhance desired features.

Different functions of ENVI 4.7 were used for all processing steps.

Geometric rectification of the imagery resample the pixel grid to fit with a map projection or another reference image.

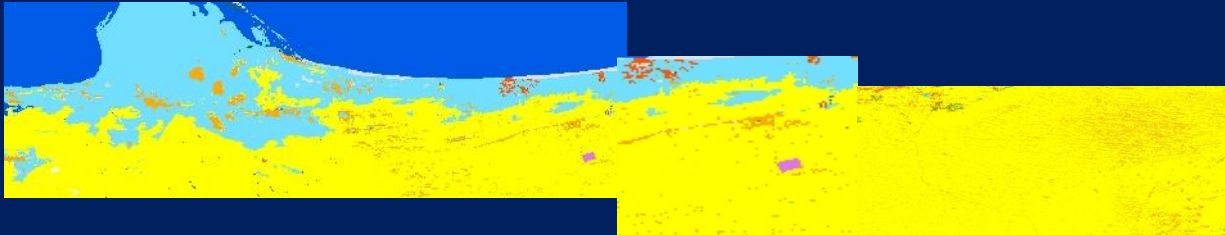
SPOT mosaic of North and south Sinai

Satellite Image processing and Building GIS database



Supervised classification was elaborated, using ground checkpoints and digital topographic maps of the study area. Accuracy assessment was carried out using 300 points from topographic and existing land cover maps.

Land Use/Land cover



| Land Use/Land Cover Class | Area | |
|---------------------------|-------------------|------------|
| | Km ² | % |
| Urban | 46.713 | 0.16 |
| Sabkha | 186.052 | 0.59 |
| Sand Dunes 1 | 12070.674 | 42.60 |
| Sand Dunes 2 | 490.094 | 1.73 |
| Sandbeaches | 111.644 | 0.39 |
| Clay Plain | 32.282 | 0.11 |
| Fish Farms | 0.854 | 0.00 |
| Cultivation 1 | 64.437 | 0.23 |
| Cultivation 2 | 161.164 | 0.57 |
| Wadi El-Arish | 4257.583 | 15.03 |
| Rockland | 10931.338 | 38.58 |
| Total | 28334.8352 | 100 |

"**Sabkha**" (0.59%) is usually found at the north of the study near to the Mediterranean coast.

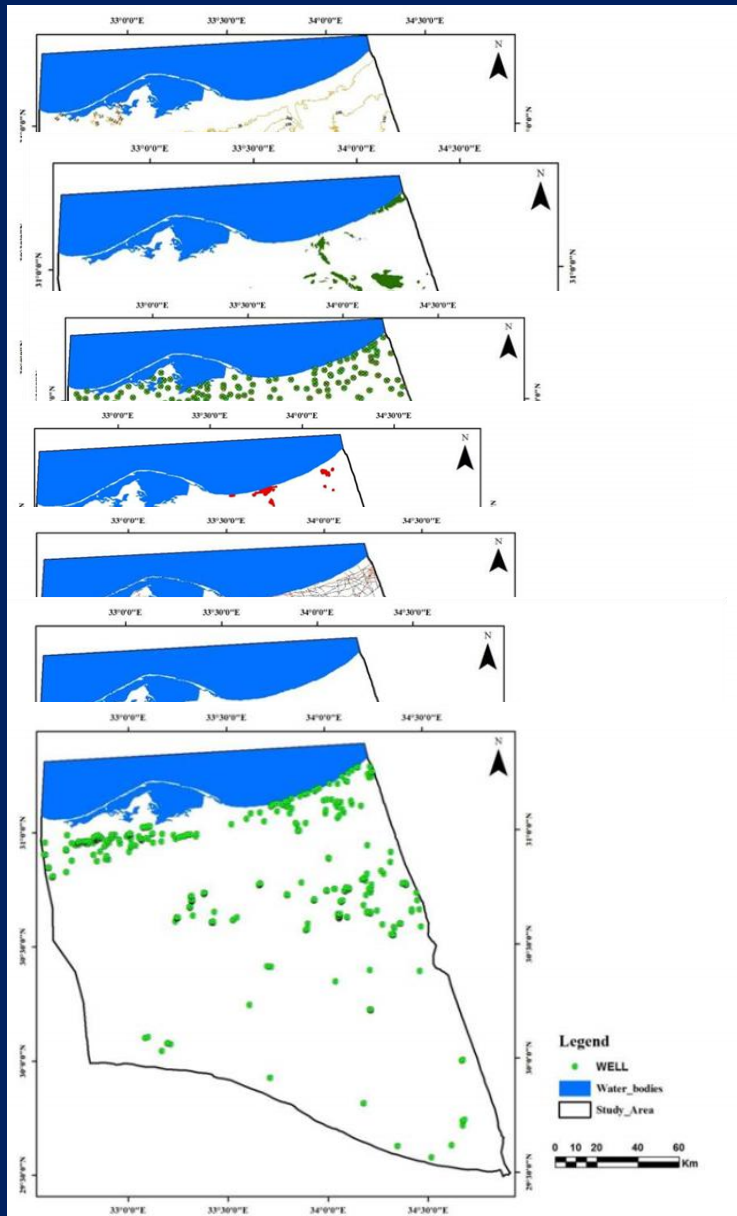
Fish Farms are located in the North West part of the study area. It is remarked that the fish ponds are limited to El Tina Plain and are not other locations at north Sinai. It is resulted from the high salinity of the soils at El Tina Plain where the local farmers try to decrease the soil salinity.. The class "**Sand dunes1**" (42.69%) refers to the complex active dunes and sand sheet. The developed areas around El-Salam canal are subjected to the risk of the dynamic activity of the dunes. .

Building GIS database

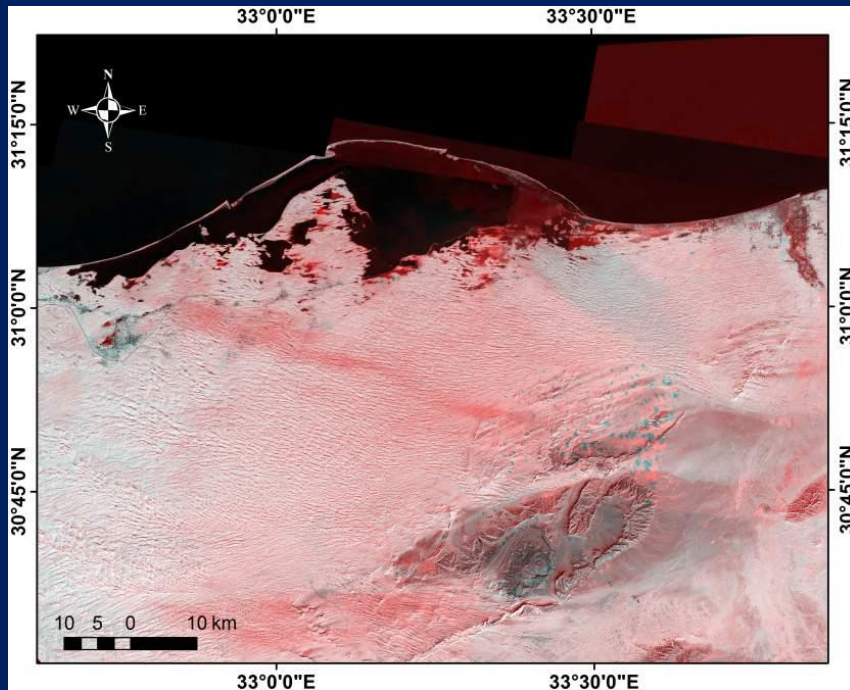
Arc-GIS 10.1 software was used for producing the digital forms of a thematic model which includes contour lines, wells locations, roads, urban, agriculture and main wadies layers were digitized using Arc-GIS software; the topographic maps (hardcopies) were scanned, imported to the GIS and geometrically corrected

The established database includes the following layers:

1. *Contour lines*
2. *Vegetation cover*
3. *The contour lines and elevation points*
4. *Urban areas*
5. *Roads networks*
6. *Main wadies*
7. *Wells location*



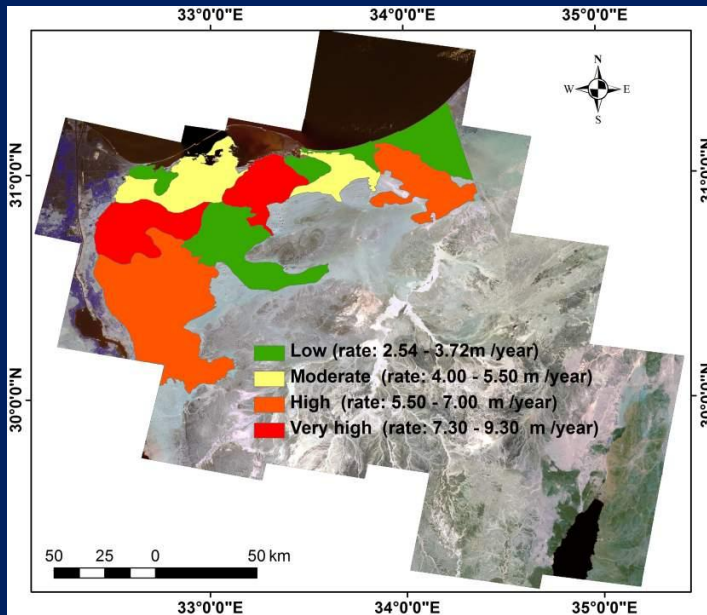
Sand Dune Movement At North Sinai



Change detection of sand dunes movement between 2000 and 2011, North Sinai.

- SPOT (2015) and LANDSAT ETM+ (2000) images were used to estimate the sand dunes movement rate at northern Sinai.
- Write Function Memory Insertion (WFMI) technique, red colors represent areas swept by moving frontiers of sand dunes.

Categories of sand dunes movement



A number of four dune movement categories according the rate of movement:

Category I (Low)

Rate of movement is 2.54 to 3.72 m per year, having a direction NW. It characterizes the coastal areas representing about 2537.42 km² (26.06%). Cultivations and vegetation are the main land use/cover in these areas.

Category II (Moderate)

Rate of movement is 4.00 to 5.50 meter per year. It dominates the areas located to the south and southeast of Lake El Bardaweel exhibiting an area of 1530.84 km² (15.72%).

Category III (High):

Movement ranges between 5.50 and 7.00 meter per year. It dominates areas of about 3811.75 km² (39.14%) located to the south of Kantara Shark and south El Sheikh Zwied cities.

Category IV (Very High)

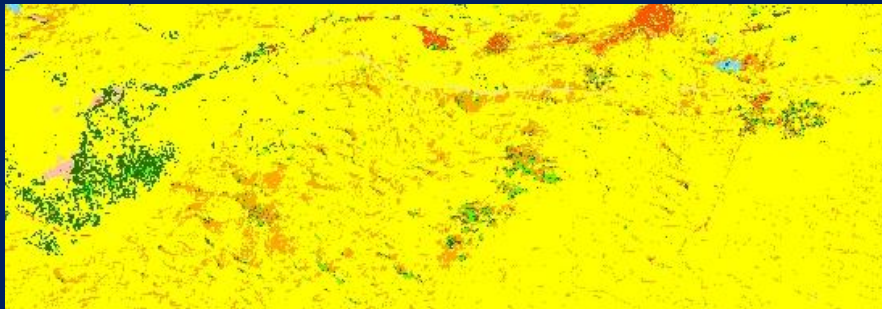
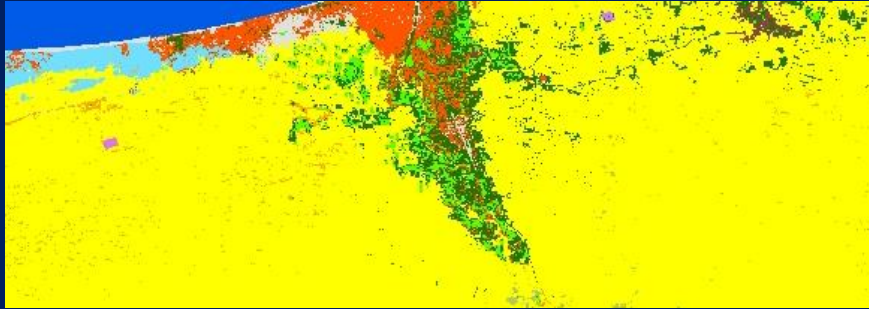
Movement in this category ranges between 7.30 and 9.30 meters per year. It characterizes an area of 1858.31 km² (19.08%) located to the south of El Salam Canal.

Categories of sand dunes movement rates at north Sinai area

Areas susceptible to different sand dune risk categories

| Rate class | Area (km ²) | Frequency (%) |
|------------|-------------------------|---------------|
| Low | 2537.42 | 26.06 |
| Moderate | 1530.84 | 15.72 |
| High | 3811.75 | 39.14 |
| Very high | 1858.31 | 19.08 |
| Total | 9738.33 | 100.00 |

Impact of Sand dunes activity



It can be outlined that the movement of sand dunes in the study area affects the following:

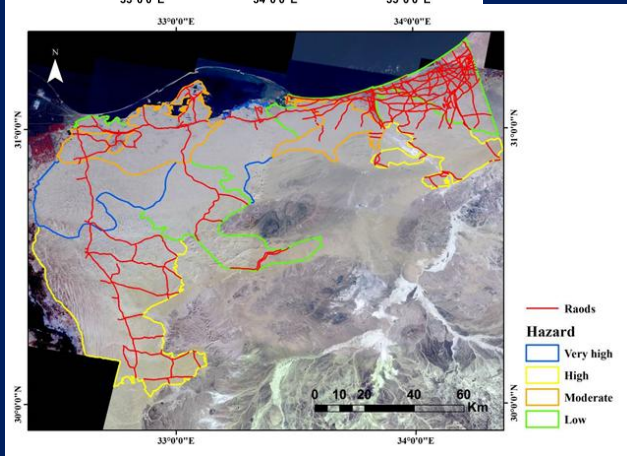
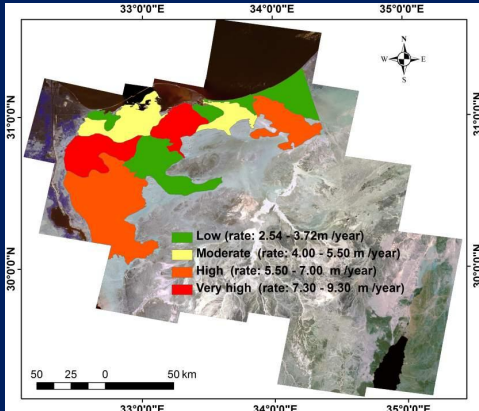
Agriculture and native vegetation,
Protectorates,

Urban areas,

Roads networks and
Irrigation canals

The class "Sand dunes 2" refers to the stable dunes, which cover an area of 490.09 km², representing 1.73% of total area.

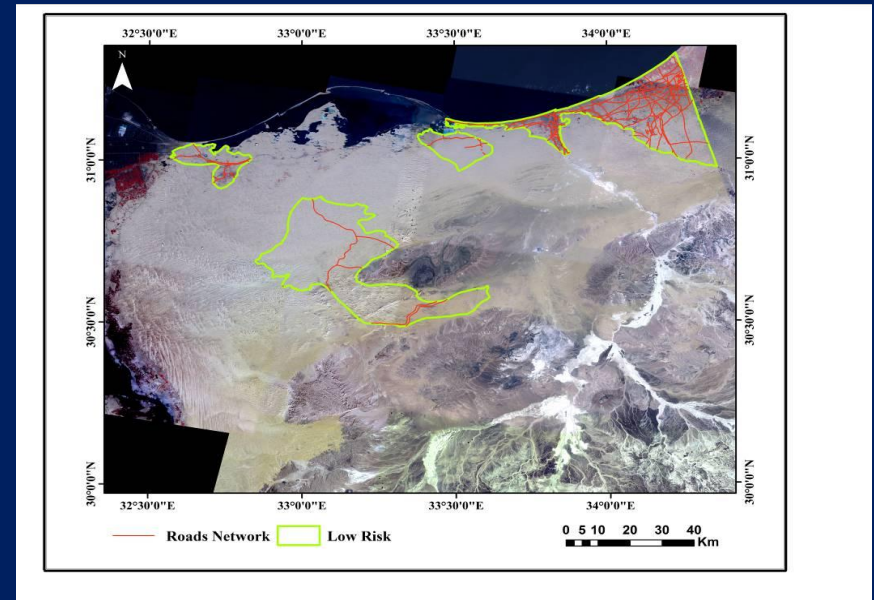
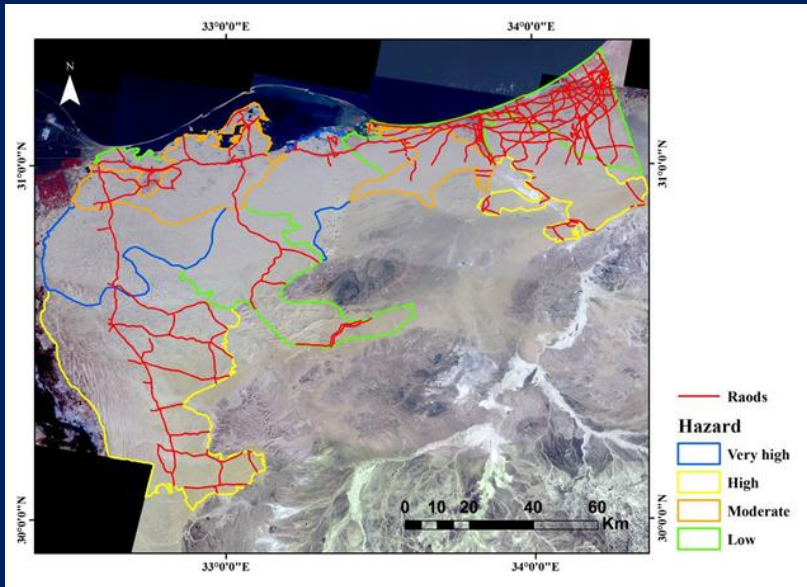
Sand dune movement rate



- In the northern district is, the movement rate of sand dunes is controlled by the climate, vegetation cover and topography.
- The southern parts of Sinai has no real effects of sand dunes, so the results of the study was concentrated on the north of Sinai.

| Layer | Measures | Very High | High Risk | Moderate Risk | Low Risk | Total Area |
|-------------|-------------------------|-----------|-----------|---------------|----------|------------|
| Hazard Area | Area (km ²) | 1858.31 | 3811.75 | 1530.84 | 2537.42 | 9738.32 |
| | % | 19.08 | 39.14 | 15.72 | 26.06 | 100 |

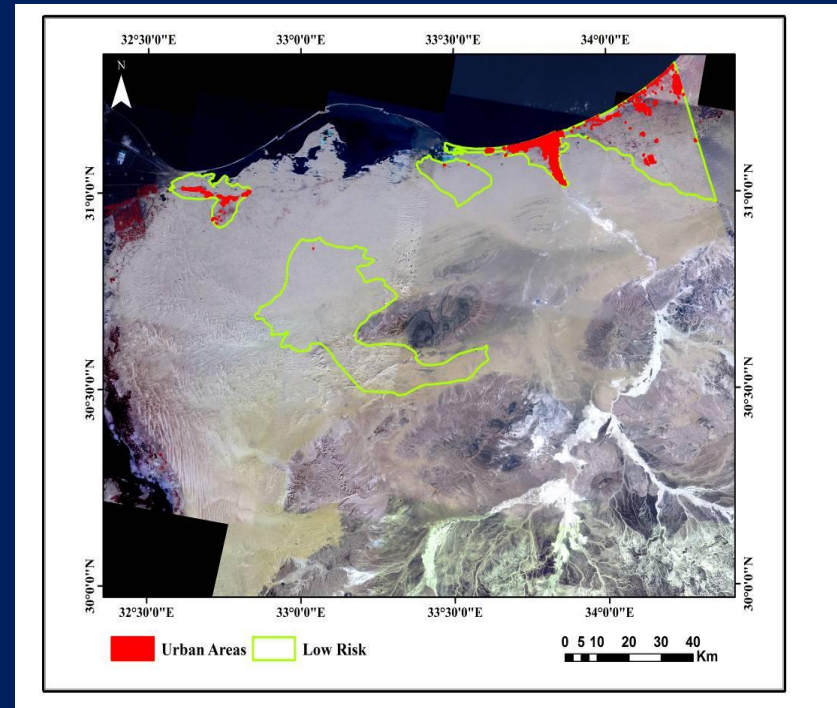
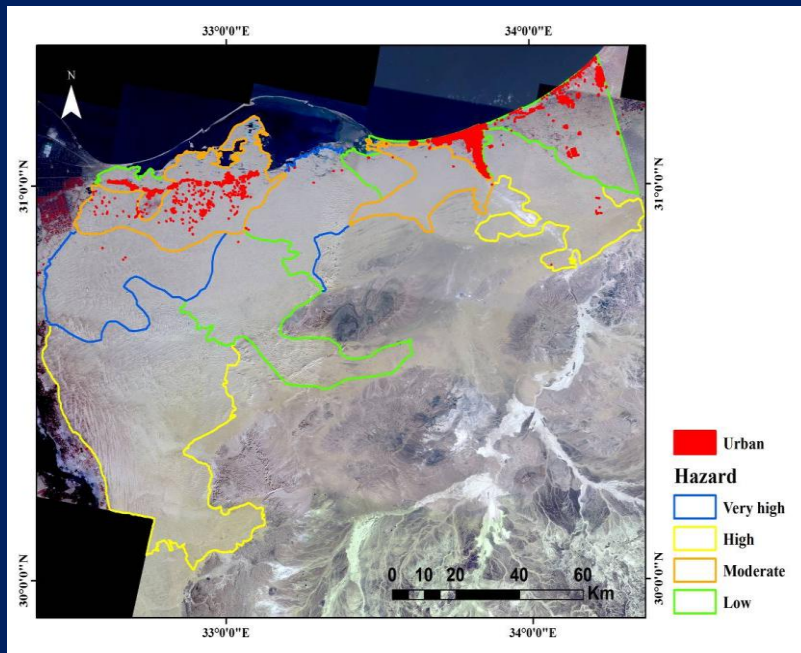
Sand dunes impact on roads network



| Layer | Measures | Very High | High Risk | Moderate Risk | Low Risk | Total Area |
|---------------|----------|-----------|-----------|---------------|----------|------------|
| Roads Network | Length | 125.23 | 1049.23 | 372.31 | 1230.16 | 2776.93 |
| Length (Km) | % | 4.51 | 37.78 | 13.41 | 44.30 | 100 |

1. About **125.23** km (i.e. 4.51 %) of the roads located under a very high risk of sand dune movement, found to the south of Lake El Bardaweel and the southwest of El Kantara Shark.
2. About **1049.23** km (37.78 %) of the rods network are located under a high risk (5 – 7 meter per year), located to the south of El Kantara Shark and East of Wadi El Arish.
3. A total of **372.31** km (i.e. 13.41 %) of the roads network are located under moderate risk of sand dune encroachment
4. About **1230** km. (44.30%) of the road network is located in the area characterised by low dune movement risk. This represented by a network located to the south of the study area and small parts east of Sahl El Tina.

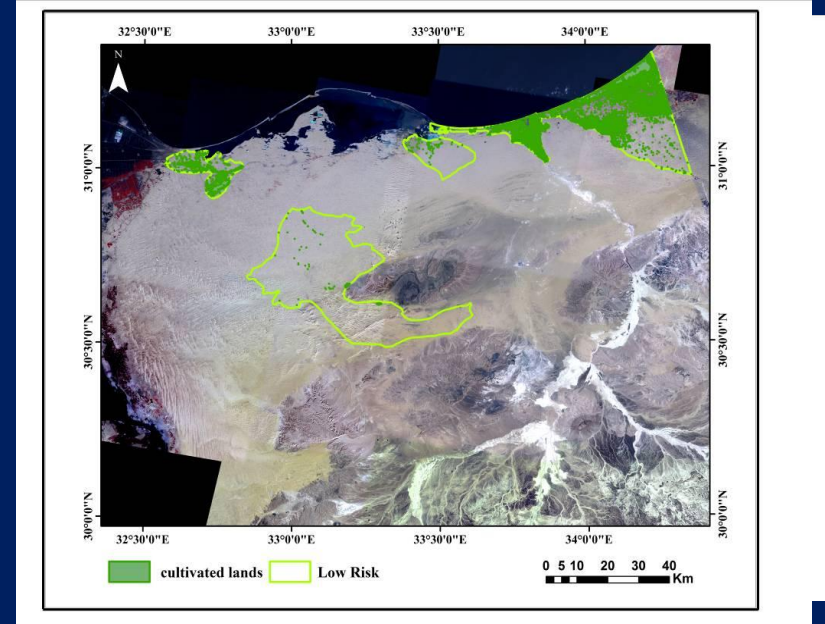
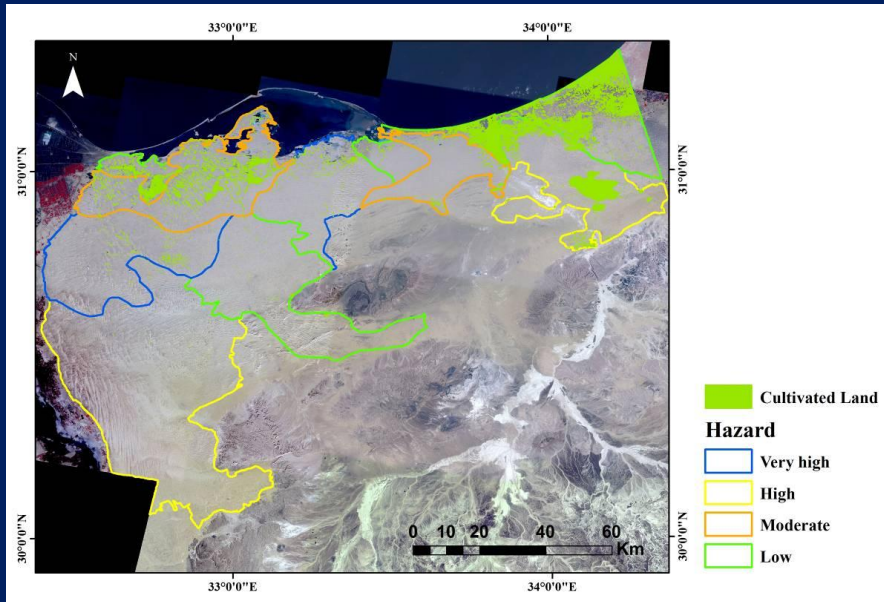
Sand dunes impact on urban areas



Sand dune encroachment risk on urban areas of North Sinai

| Layer | Measures | Very High | High Risk | Moderate Risk | Low Risk | Total Area |
|------------|-------------------------|-------------|-------------|---------------|--------------|------------|
| Urban Area | Area (km ²) | 0.11 | 0.24 | 11.25 | 55.16 | 66.76 |
| | % | 0.17 | 0.36 | 16.85 | 82.62 | 100 |

Sand dunes impact on cultivated areas



Sand dune encroachment risk on cultivated areas of North Sinai

| Layer | Measures | Very High | High Risk | Moderate Risk | Low Risk | Total Area |
|-----------------|-------------------------|-----------|-----------|---------------|----------|------------|
| Cultivated Land | Area (km ²) | 1.24 | 92.49 | 24.88 | 158.59 | 277.20 |
| | % | 0.45 | 33.37 | 8.97 | 57.21 | 100 |

Conclusions

1. Sand dunes movement rate is controlled by the climate, vegetation cover and topography. Due to variable landscape at North Saini, different sand dune movement rat categories exist.
2. The northern coastal zone is inhibited by different sustainable development activities as urban, agricultural, roads and tourism, it proved to be the most affected by sand dunes activities.
3. Sinai is a vital strategic area, which needs intensive efforts towards sustainable development.
4. North Sinai has potential importance supporting the national development programs. Integrating remote sensing data with digital land resources maps, using GIS, lead to point out the priorities for elaborating successful sustainability.
5. Sand dunes activity hazards have to be analyzed, where precautions must be considered.