



## Applications of RS & GIS for Tsunami and Sea Surges Risk Assessment Along the Coast of Karachi

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Coastal Areas are prone several hazards like storm surges inundation due to sea level rise or coastal flooding, Tsunamis, and so on. However, the condition is more disastrous, if the coast is highly built up and populated. Pakistan occupies a coastline of 1046 kms. The most developed part of it is the city of Karachi. The coast faces storm several times during the monsoon season and there is a sea level rise threat also in the coming years. The coast of Pakistan also lies near the plate boundaries of two major plates: Indo-Australian and Eurasian plate, and two minor plates the Arabian and Iranian Plates. In case of any major earthquakes in the Arabian Sea, tsunami is a big hazard, which may engulf many important and heavily built-up commercial, residential, industrial, and sensitive areas of armed forces. The aim of the study is to analyze the loss in case of inundation of the Karachi Coast, with Remote Sensing and GIS Techniques.

**Keywords:** GIS, RS, Coastal Inundation, Tsunamis, Sea Surges, Karachi.



## Introduction:

Globally the Coastal areas have experienced significant damage and losses because of tsunamis and tidal surges. Landslides, volcanic eruptions, earthquakes, and other disturbances of the water bring on numerous natural disasters. It is essential to comprehend the mechanisms underlying these calamities and anticipate their occurrence to lessen their impact. The use of Geographic Information Sciences (GIS) and Remote Sensing (RS) has made it possible to analyze and forecast the effects of sea surges and tsunamis.

The Karachi Coast is considered moderate to highly sensitive to natural hazards such as cyclones, storm surges, and tsunamis, according to a study conducted by the National Institute of Oceanography in Pakistan [1]. According to the study, coastal areas with dense populations, poor warning systems, and poor infrastructure are the most vulnerable. Human-induced hazards like coastal erosion and pollution are also affecting the coast of Karachi. Natural hazards are now more likely to occur because of the decline of mangroves and the deterioration of coastal ecosystems [2].

Overall, the coast of Karachi is considered a hazard-prone region that requires significant risk assessment as well as management strategies to minimize the potential consequences of natural disasters. The region with inadequate infrastructure and dense population are more vulnerable, hence, initiatives should be taken towards the improvement of coastal protection measures and early warning systems are required. [1][3][4][5].

### Applications of GIS in Tsunami and Sea Surges:

GIS technology is used extensively to analyze and model the impact of tsunamis and tidal surges on coastal regions. Digital elevation models (DEM) of coastal areas may be produced with GIS, and these models can be used to estimate tsunami inundation possibilities. Maps of tsunami and sea surge inundation created using GIS assist emergency responders in planning evacuation routes and locating high-risk regions. The maps may also identify locations requiring more infrastructure to withstand the effects of sea surges and tsunamis [6]. The effects of sea level rise on coastal regions may also be examined using GIS. The forecast of rising sea levels by technology can assist authorities or policymakers in formulating strategies for the future.

### Applications of RS in Tsunami and Sea Surges:

The consequences of tsunamis and sea surges were analyzed and predicted using remote sensing technology. RS can detect erosion or variations in sea level that affect the shore. Researchers have monitored changes in the coastal vegetation, which measured the effects of sea surges and tsunamis using satellite imagery. Oceanic disturbances that cause tsunamis and sea surges can also be monitored by remotely sensed data. Researchers have used satellite imagery to monitor the temperature and currents of the ocean to predict the occurrence of tsunamis and sea surges [7].

### Study Area:

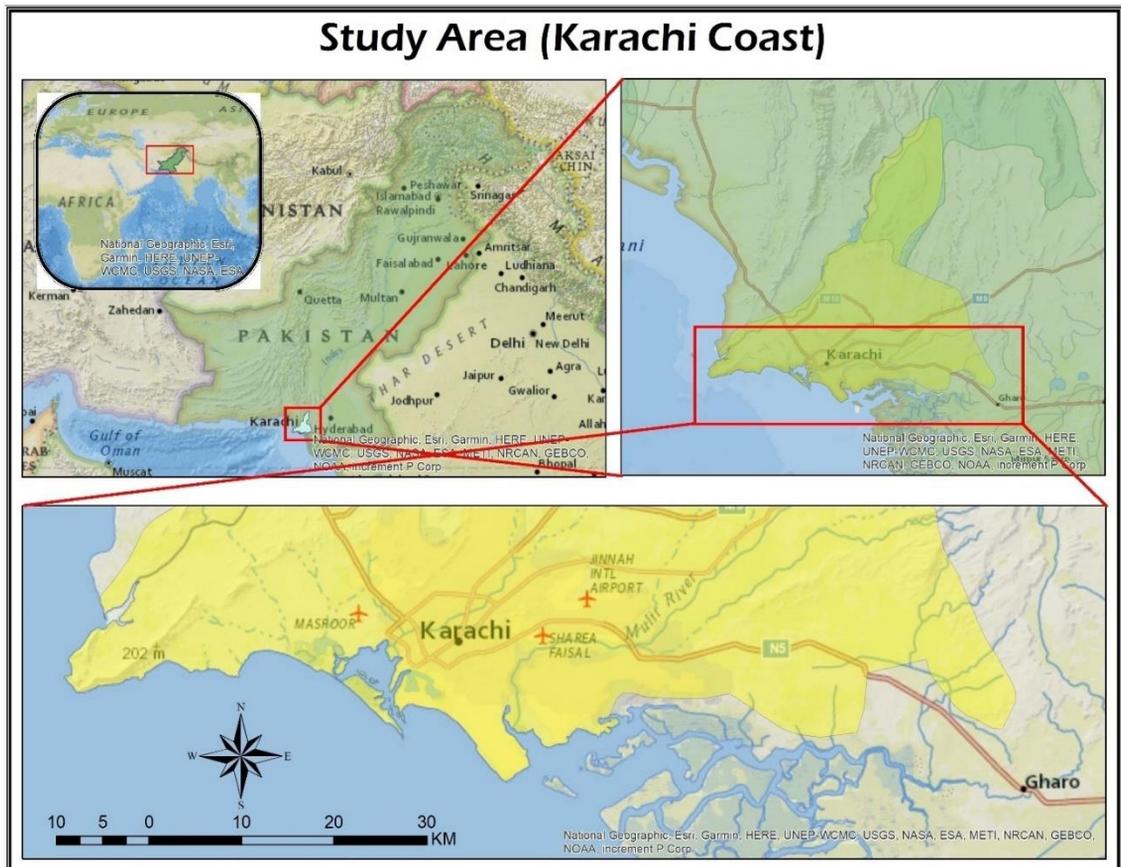
Karachi is a tropical city, having semi-arid climate. It receives rainfall during summer Monsoon, i.e. from July to September. The coast of Karachi spreads over 70 Km from Cape Monze in the west to Port bin Qasim in the east (Figure: 1). Most of the part of the coast is densely populated and has major industrial, commercial, and residential areas that make it vulnerable.

Some of the most vulnerable areas on the Karachi Coast are listed below:

- **Keamari Town:** It is located in the west of the city and it is highly vulnerable to natural disasters that can affect its dense population. Karachi Port is also part of Keamari Town.
- **Lyari Town:** This posh town is home to a large population with poor living conditions that is considered a highly vulnerable region.

- **Hawksbay:** It is among the most popular tourist destinations in Karachi. Different beautiful sites with coastal features present along the shoreline attract tourists. The vulnerability is due to its low elevation and exposure to the sea.
- **Ibrahim Hyderi:** A fishing village located on the southeastern side of the coast. The low elevation also makes it more vulnerable.
- **Port Qasim:** It is located in the eastern part of the city's coast. Port Qasim is the busiest port in the country. It is vulnerable to natural disasters because of its low elevation.
- **Clifton and DHA:** Clifton and Defense Housing Authority (DHA) are quite vulnerable areas as they are low-laying and human dumped sites. They both are posh areas that cover a huge commercial and business sector of the city as well. Clifton Beach and Sea View Beach are tourist sites that lie within this region.

These are some most vulnerable areas on the coast of Karachi while some other areas might also be at risk due to their locations and characteristics [1][3][4][5].



**Figure1:** Study Area

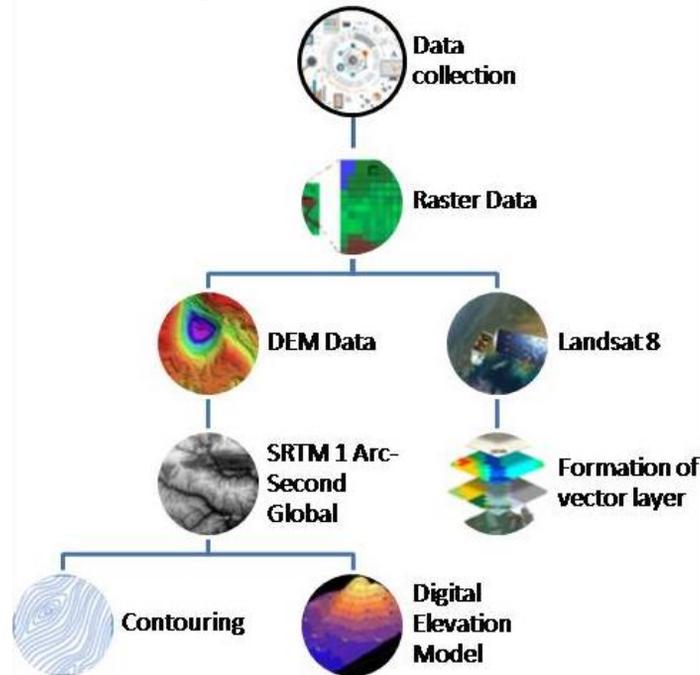
### Materials and Methods:

All the methodology used to perform this research work involves GIS & RS techniques. SRTM-1 Arc-Second Global's image is used to create a Digital Elevation Model (DEM) and contouring. The image was acquired from NASA Earth Data. ArcScene and ArcGIS Pro were used for data processing and mapping (Figure 2). The SRTM data is used to extract a general elevation that helps to recognize the areas at high risk and the Landsat image is used to locate the major land use cover near the coast exposed to the hazards.

Remote Sensing data and GIS technologies have given a broader platform for monitoring and mapping, analyzing, planning, and decision-making. Since; large-scale spatial data like geomorphic or manmade features on a regional scale with lesser time and effort can be

acquired and analyzed accurately. The scientific society has globally approved the accurate judgment of the RS and GIS technologies[8][9].

SRTM data has proved to be quite, helpful in the study of the general Earth surface, the geomorphology, and related processes. Hence, it can be an integral part of planning, risk assessment, hazard management, and mitigation. Large-scale hazards like Storms, Tsunamis, coastal flooding, and inundation with their impact can be monitored frequently with lesser ground surveys, and give better outcomes if analyzed along with other data like seismic data and meteorological data. [10] adapted a similar approach to stress the importance of remote sensing and other observational platforms that play important roles in earth measurement, decision support systems, and hazard management.

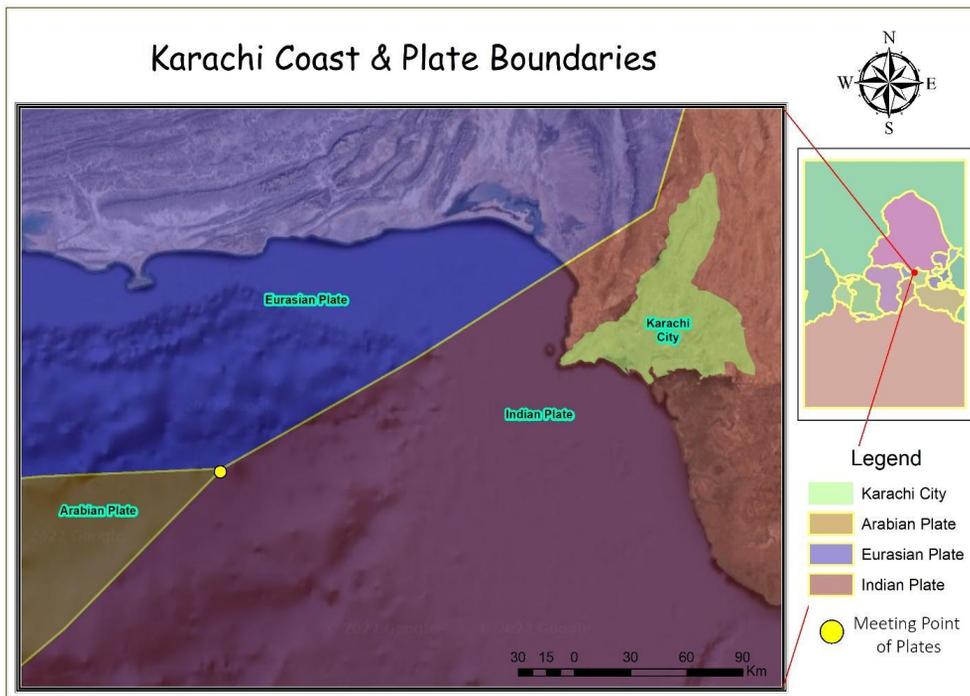


**Figure 2:** Methodological framework

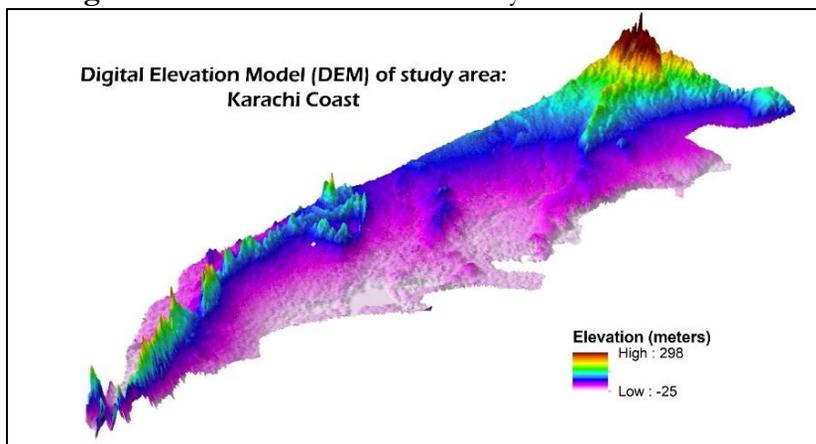
In a mega city like Karachi where greater population clusters and commercial as well as industrial activities thrive, satellite technology and GIS plays a significant role in mapping and planning. Geospatial techniques play a significant role in regular monitoring and recording multitemporal variations of LULC (land use and land cover) [11][12][13][12][14]. Different types of landuses, occurring along the coast were identified and mapped through Landsat satellite image. Google Earth Pro also used to identify the places. Remote sensing data and techniques particularly land sat images plays a vital role in the study and classification of large-scale land use and land cover features. [15].

### Results and Discussions:

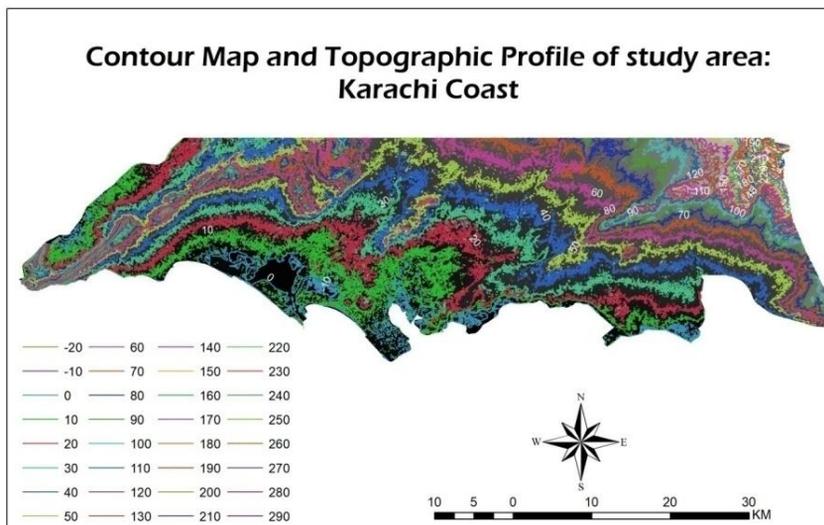
The conjunction of Arabian, Eurasian, and Indian plates lies approximately 220 km away from the city (Figure 3). This distance may differ from east to west at the coast. However, tectonic activity between these three plates still affects the coast and the surrounding areas in various ways i.e. seismic activity, tsunami, geological feature, geological hazard, or sea level rise & subsidence, which can cause damage to nearby infrastructure and human life of vulnerable areas and it may also impact on ecology and local climate.



**Figure 3:** Location of Plate Boundary Near Karachi Coast

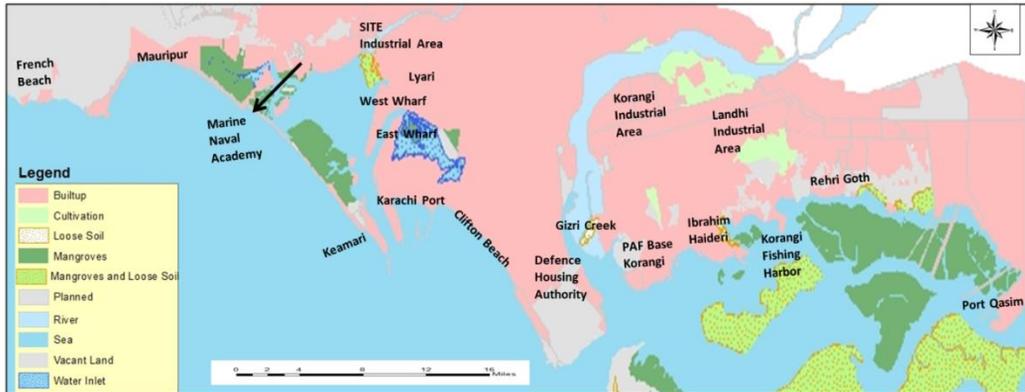


**Figure 4:** Digital Elevation Model (DEM) of Karachi Coast



**Figure 5:** Contour map and topographic profile of Karachi Coast

DEM is generated using an SRTM image to see the altitudes of the coastal area of Karachi. The range of the city lies between -25 to 298 m. The Dem and topographic profile of the area gives an idea that elevations till 20 meters are at high risk without any obstruction (Figure 5). The topographic profile of Karachi, if compared with the land use map of Karachi Coast reveals the fact that many of Karachi's highly built-up area are concentrated within the elevation of 20 to 30 meters. These areas include residential, commercial and industrial areas as well and along with these areas several sensitive and strategic areas are found at these elevations (Figure 6).



**Figure 6:** Lanusse and Land Cover along Karachi Coast

### Conclusion:

It can be concluded that the GIS and RS are useful methods for evaluating and predicting the effects of sea surges and tsunamis on coastal regions. Sea-level rise forecasts, inundation maps, and oceanic disturbances that might cause tsunamis and sea surges can be studied and monitored with the help of geospatial technology. The study provides a unique knowledge about the total loss in case of inundation due to Storm surges or Tsunamis and so on. Emergency responders may reduce property damage, minimize fatalities, and better prepare for the effects of natural disasters by using the application of remote sensing and geographical information sciences for disaster management.

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