EMERGENCY PLANNING IN NORTHERN ALGERIA BASED ON REMOTE SENSING DATA IN RESPECT TO TSUNAMI HAZARD PREPAREDNESS

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ABSTRACT

LANDSAT ETM and Digital Elevation Model (DEM) data from the coastal areas of Algeria were investigated in order to detect traces of earlier tsunami events. Digital image processing methods used to produce morphometric maps - such as hillshade, slope, minimum and maximum curvature maps based on the SRTM DEM data - contribute to the detection of morphologic traces that might be related to catastrophic tsunami events. These maps combined with LANDSAT ETM and seismotectonic data in a GIS environment allow the delineation of areas with potential tsunami risk. The evaluations of LANDSAT ETM imageries merged with digitally processed and enhanced SRTM data clearly show areas that must have been flooded in earlier times. In some cases morphological traces of flood waves as curvilinear scarps open to the seaside or traces of abrasion are clearly visible.

1. INTRODUCTION

Images from earth observing satellites have become a valuable support tool for tsunami damage detection in the aftermath of the disaster. This contribution, however, considers the use of remote sensing data for the detection of traces indicating past, catastrophic tsunami events as it can be assumed that coastal areas that were hit in the past by catastrophic tsunamis might be affected by similar events in the future again. This study concentrates on tsunami risk mapping for areas where no severe tsunami has occurred recently, but the geomorphologic and topographic features and characteristics are similar to areas hit by recent catastrophic tsunamis as Sumatra and where historical records of tsunamis are available and reliable. A tsunami hazard map of such an area that predicts the location of future tsunami occurrences is required. Most detailed maps of those areas susceptible to tsunami flooding are an important step towards disaster preparedness and mitigation.

The coastal areas of Northern Algeria are investigated more detailed with the help of remote sensing data in order to detect typical geomorphologic and hydrologic features assumed to be related to past tsunamis as described in Fig.1. The areas prone to flooding hazard or to landslide hazard are delineated and mapped. These maps could be used as contribution to emergency planning in coastal areas of Algeria.

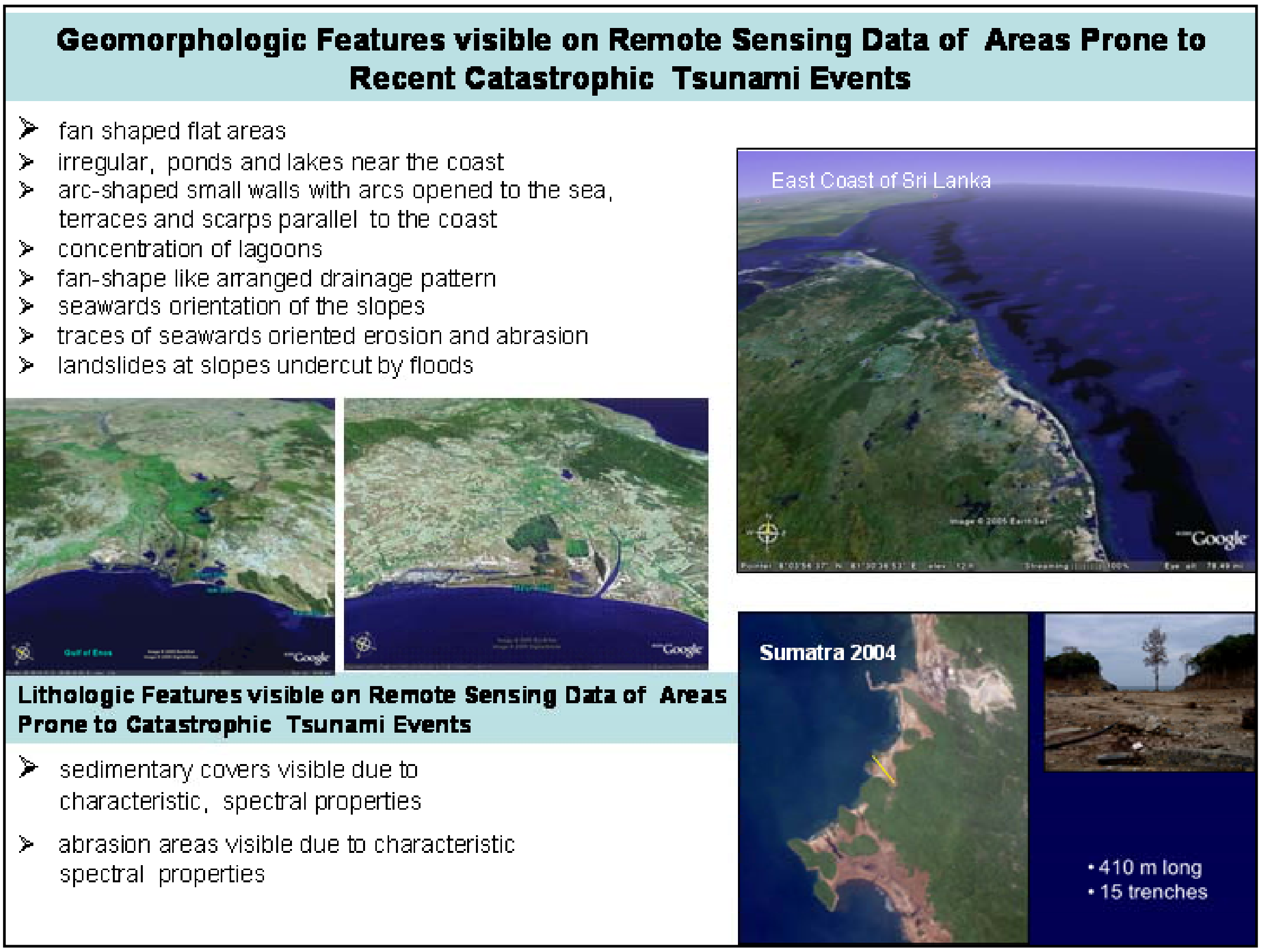


Fig.1: Typical morphologic and hydrologic features of tsunami prone areas

2. APPROACH

A concept of multi-hazard assessment is developed based on remote sensing data and GIS methods. This approach enables to asses the geohazards in respect to their different and complex dependencies. It focuses on a hazard map that might be useful as base for local and regional planning decisions of local governments and stakeholders of the civil society. The findings can be converted to recommendations for the local governments such as towns and villages in order to plan disaster-reducing activities.

This study considers the support provided by remote sensing data, including DEM data acquired by Space Shuttle Missions, and a GIS based spatial databases for the delineation of potential risk sites in Algeria. On a regional scale the areas of potential tsunami risk are determined by an integration of remote sensing data, geologic, seismotectonic and topographic data. The evaluation of digital topographic data is of great importance as it contributes to the detection of the specific geomorphologic/ topographic settings of tsunami prone areas. LANDSAT ETM and DEM data were used as layers for generating a Tsunami Hazard GIS and combined with different geodata and other thematic maps.

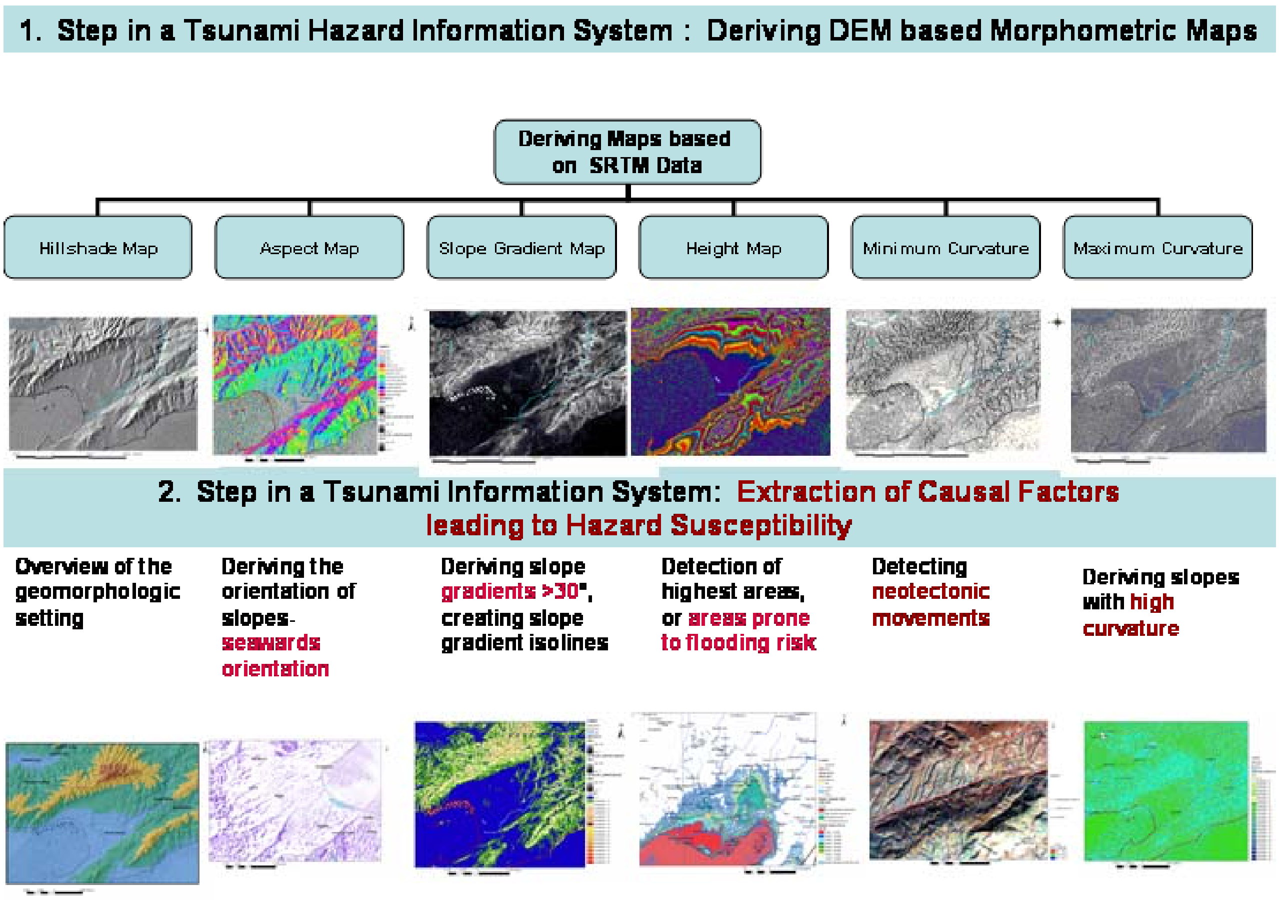


Fig.2: Deriving Morphometric Maps based on SRTM Data and Extraction of Causal Factors leading to Natural Hazards (Theilen-Willige, 2006)

For the objectives of this study digital elevation data have been evaluated: **S**huttle **R**adar **T**opography **M**ission - SRTM, 90 m resolution) data provided by the University of Maryland, Global Land Cover Facility (http://glcfapp.umiacs. umd.edu: 8080/esdi/) and GTOPO30 data provided by USGS (http://www.diva-gis.org/Data.htm, 1 km resolution) were used as base maps.

The digital topographic data were merged with LANDSAT ETM data (Band 8: 15 m resolution). For enhancing the LANDSAT ETM data digital image processing procedures have been carried out. Various image tools delivered by ENVI Software/ CREASO were tested, for example to find the best suited contrast-stretching parameters. With digital image processing techniques maps can be generated to meet specific requirements considering risk mapping. For getting a geomorphologic overview SRTM data terrain parameters were extracted from a DEM as shaded relief, aspect and slope degree, minimum and maximum curvature or plan convexity maps using ENVI and ArcMap software (Fig.3). Many of the morphometric parameters measured from a DEM vary with the size of grid used to model the surface (WOOD, 2002). The various data sets as LANDSAT ETM data, topographic, geological and geophysical data from the study regions were integrated as layers into GIS using the software ArcView GIS 3.3 with the extensions Spatial Analyst und 3D-Analyst and ArcGIS 9.1 of. Other geodata as provided by ESRI ArcIMS Server or USGS Natural Hazards Support System were included, so earthquake data or bathymetric maps. As a complementary tool Google Earth Software was used in order to benefit from the 3D imageries of the various investigation areas (http://earth.google.com/).

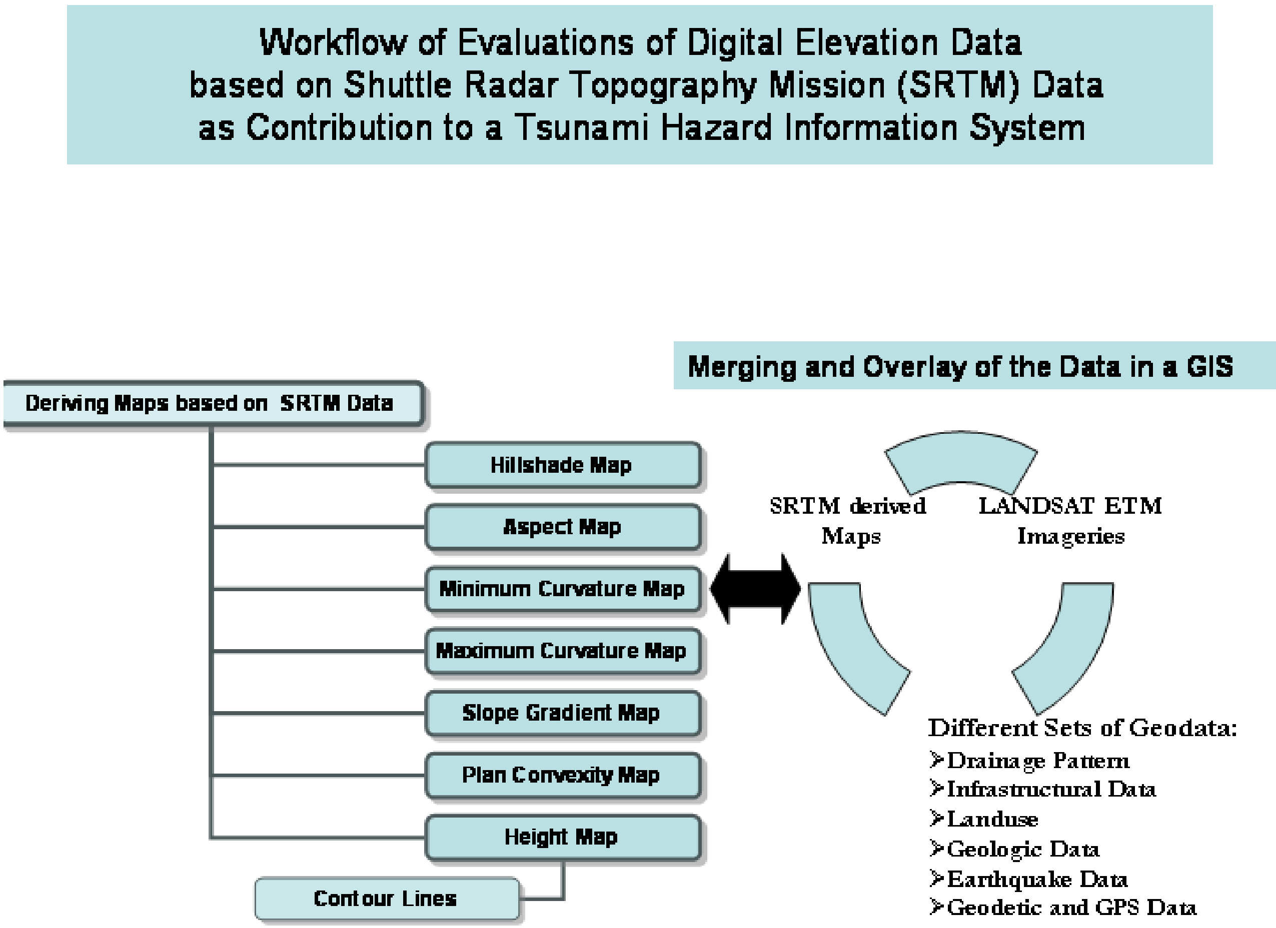


Fig.3: Workflow

Geomorphometric parameters as slope degree, minimum or maximum curvature provides information of the terrain morphology indicating geomorphologic features (see Fig.2) that might be related to tsunami events. These SRTM derived, morphometric parameters correspond to groups of 0, 1st and 2nd order differentials, where the 1st and 2nd order functions have components in the XY and orthogonal planes. A systematic GIS approach is recommended for tsunami risk site detection as described in Fig.3 extracting geo-morphometric parameters based on the SRTM DEM data as part of a Tsunami Information System. LANDSAT ETM data were used as well for deriving information of surface-near water currents in the coastal areas that might help to a better understanding of the influence of the coastal morphology on streaming mechanisms

Fig.6 including different geodata sets describes the next step schematically

Potential risk sites for hazardous tsunami waves were identified by analyzing areas in Algeria showing heights below 20 m above sea level based on GTOPO30 height data (Fig.4). These areas below 20 m height were studied then more detailed evaluating LANDSAT ETM and SRTM data.

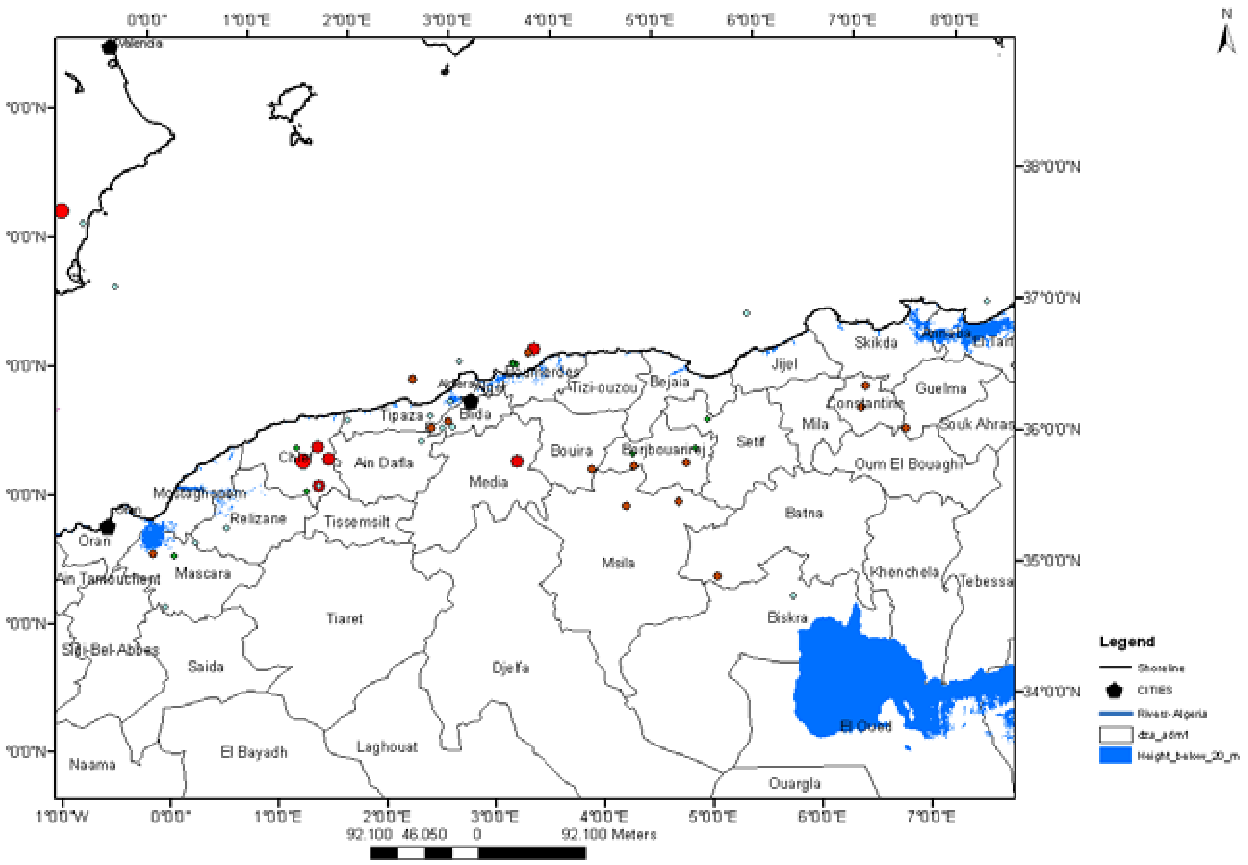


Fig.4: Potential tsunami hazard sites in Algeria

3. EVALUATION OF SRTM AND LANDSAT ETM DATA FROM COASTAL AREAS OF ALGERIA

Investigation areas were selected where the evaluation of SRTM, LANDSAT ETM and other geodata allows the assumption that catastrophic tsunami events might have occurred in the geologic past. As first example the area of Gulf of Stora and Bone/ Northeast Algeria is presented.

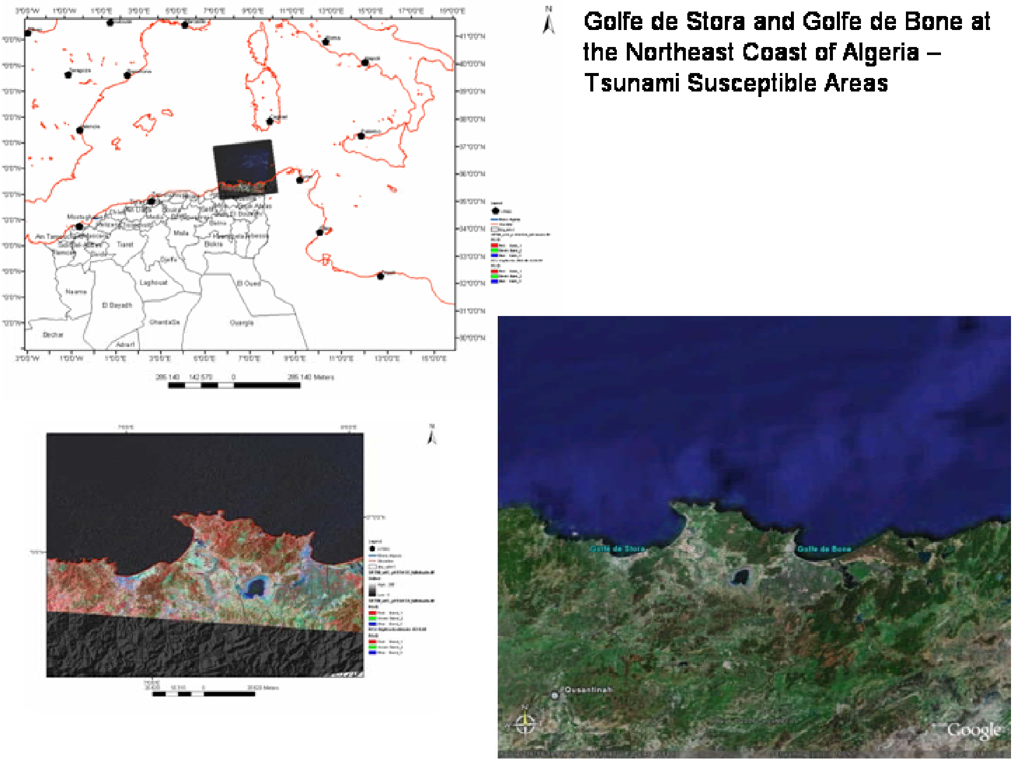


Fig.5: Position of the investigation area

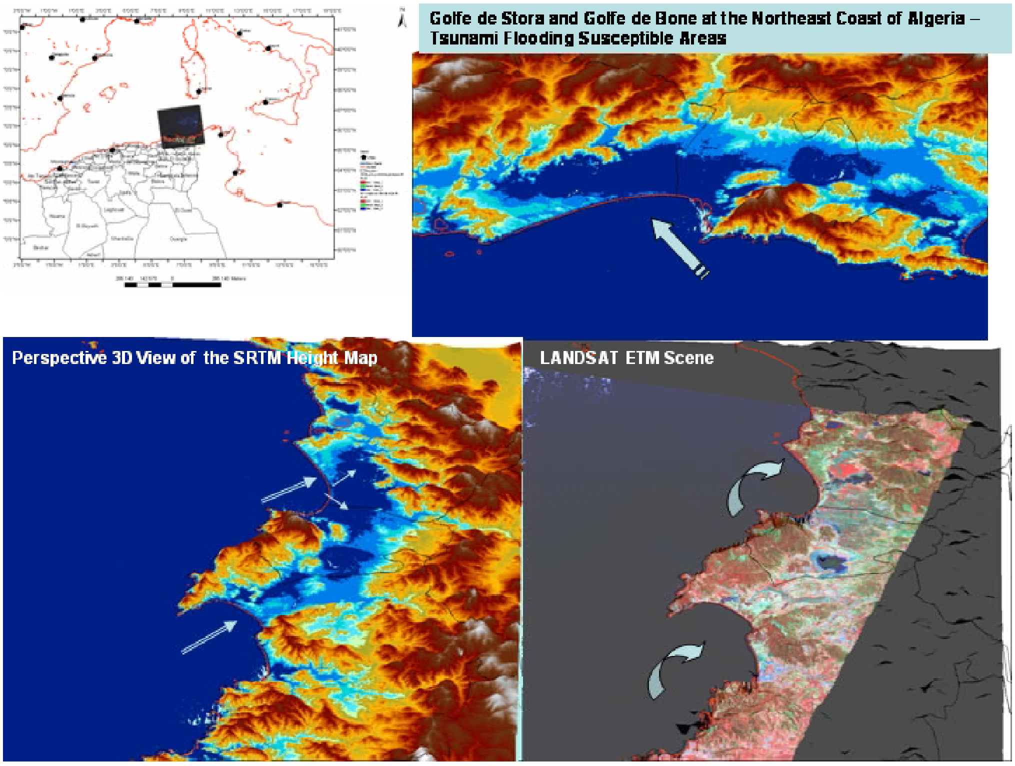


Fig.6: Perspective 3D views of the SRTM based height map and LANDSAT scene

Fig.7 presents a map indicating areas susceptible to flooding in case of a mega-tsunami. A map like this could be of use for land use and emergency planning. In the lowest areas (<10 m above sea level) the potential flooding risk must be considered.

Potential Tsunami Flooding Sites in Northeast Algeria

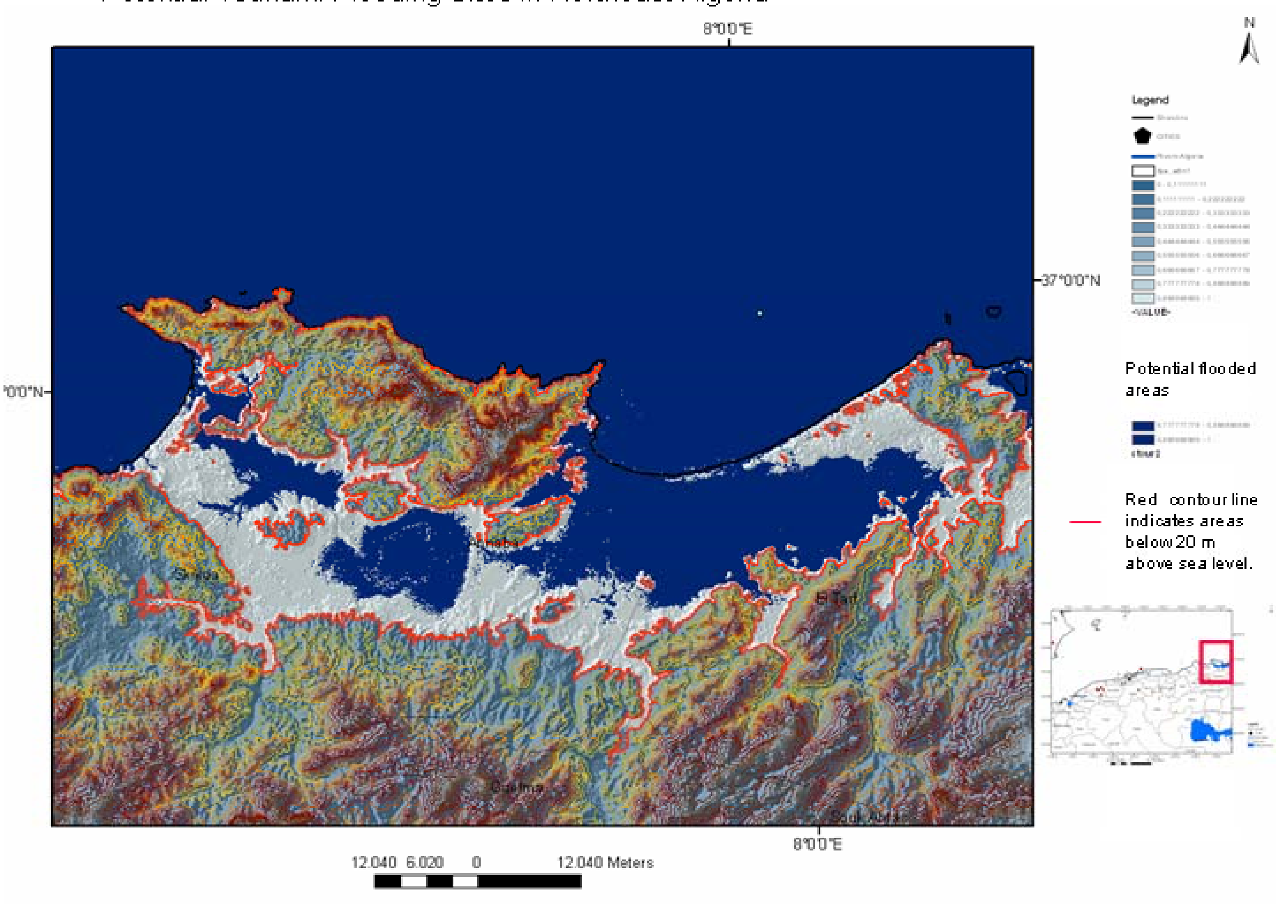
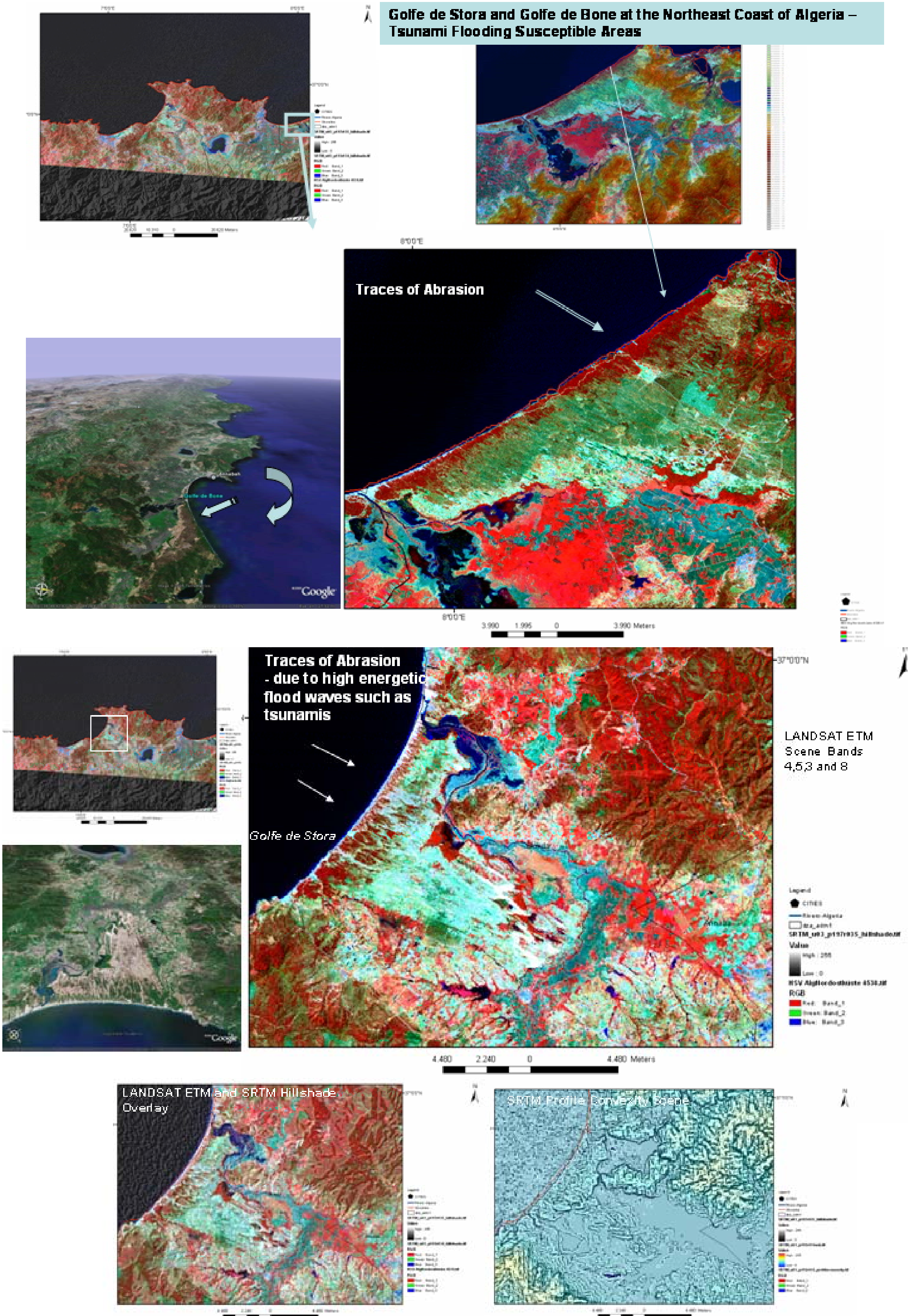


Fig.7: Areas susceptible to flooding in case of a mega-tsunami as indicated by the red contour line and blue colours

Fig.8 shows amplifications of LANDSAT ETM scenes of this area allowing the detection of traces of erosional features that could be explained by abrasion. Linear and parallel traces of erosion, oriented perpendicular to the shore, ending in arc-shaped walls, opened towards the sea, are obviously related to catastrophic flood waves.



Figs. 8 a and b: Traces of catastrophic flooding visible on LANDSAT ETM scenes and morphometric maps

The next example for the use of remote sensing and GIS methodology for tsunami hazard site detection is shown from the northwest coast (Fig.9). The evaluations of LANDSAT ETM data and SRTM based morphometric maps lead to the conclusion that there is a strong evidence of past, catastrophic tsunami events.

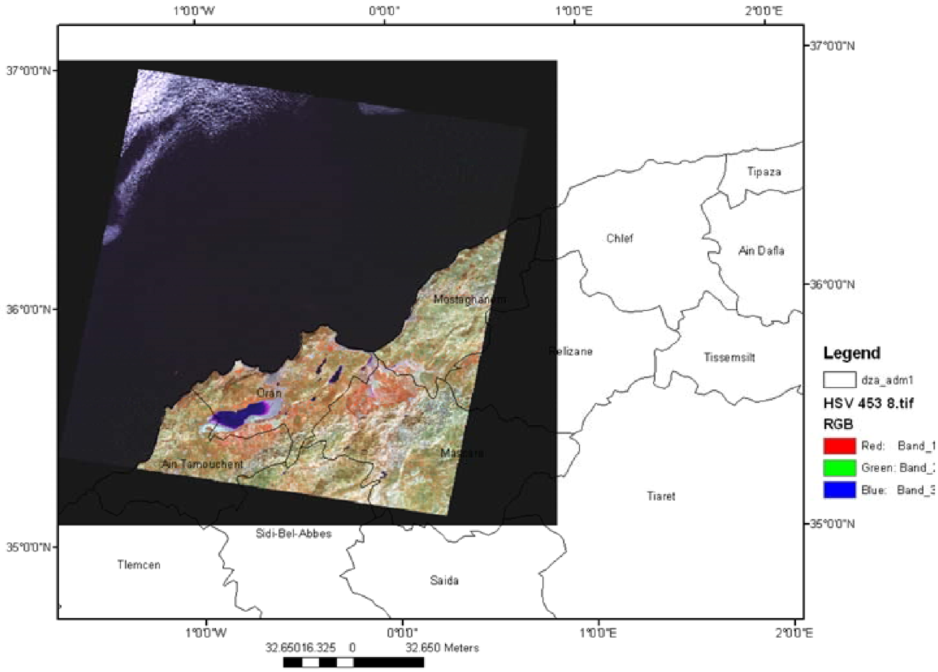


Fig.9: Position of the example in NW Algeria

Fig.10 presents a perspective view of the area.

Fig.10: Perspective View based on Google Earth data

The following Figs.11 a-c show the results of the merge of SRTM morphometric maps and LANDSAT ETM scenes enhancing areas susceptible to flooding.

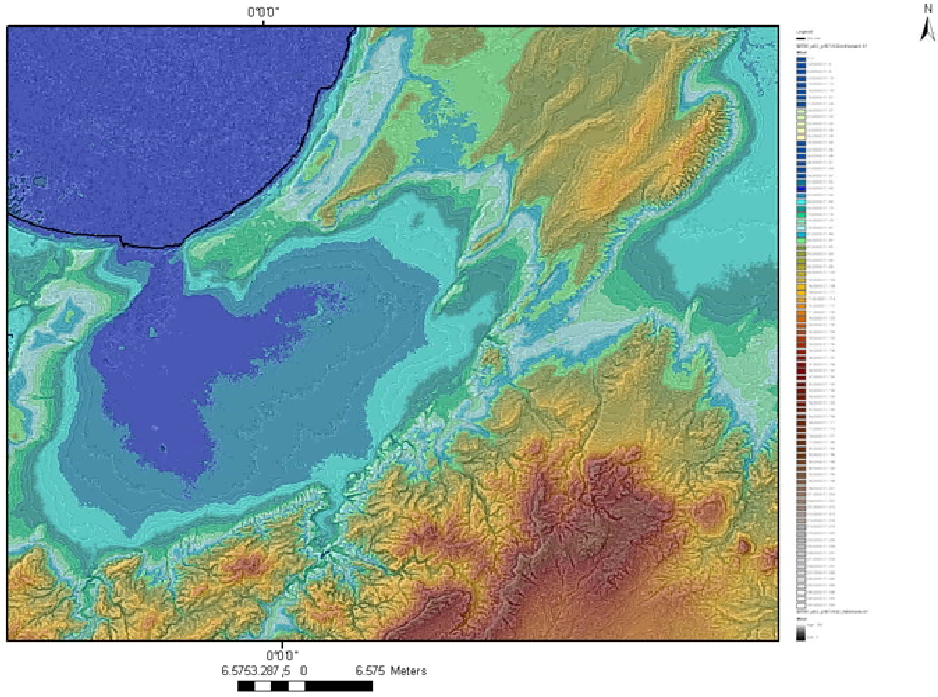


Fig. 11 a: Height map based on SRTM DEM data indicating the lowest areas

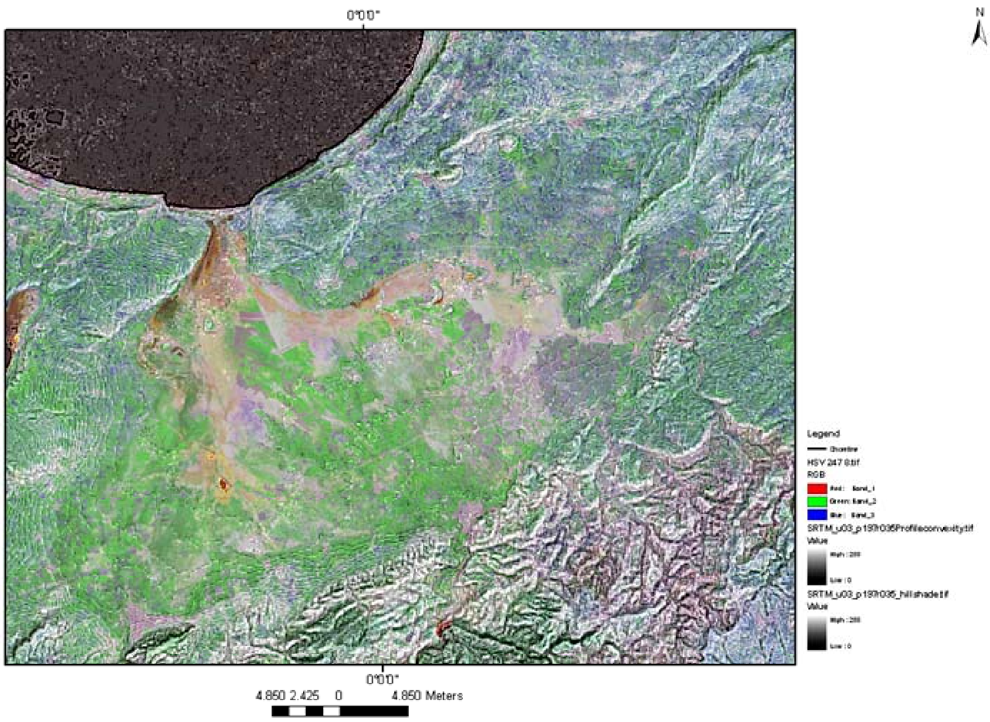


Fig. 11 b: LANDSAT ETM scenes (different band combinations) merged with SRTM Profile Convexity morphometric map