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Tsunami Evacuation Planning and Mapping along Coastal Area of Porbandar City Gujarat, India

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Abstract

Uncompromising natural Hazard, like e.g. tsunamis or quake, frequently guide to misery with spectacular consequences. In these days natural disasters caused loss hundreds of thousands of human, defloration to infrastructure, loss of billions of money worth of material and disturbance of financial activity.The overall plan of action of this study focuses on developing a tsunami evacuation map to transfuse to a tsunami early warning information system for Indian subcontinent. This presents the hazard mapping for Tsunami and strategy for Tsunami evacuation for Porbandar city(Latitude: 21.6300° N Longitude: 69.6000° E) The need for the study is to conversant people for the hazard of tsunami and also saving maximum lives when tsunami occurs there in possible shortest time. The past historical earthquakes of Tsunamigenic source of Makran subduction zone which was responsible for causing tsunami on western coast of Gujarat state of for Indian subcontinent are studied. This work is about natural disaster evacuation planning and management for study area. Tsunamis can represent a significant risk to the population and cause huge economic failure in many coastal regions. The results of this study can be utilized in many useful way such as, by public policy and decision makers in developing disaster management strategies.

Keywords:- Tsunami risk zone maps , MSZ ,Evacuation

I. INTRODUCTION

Tsunami is a Japanese word as written right side with the English translation,"harbour wave". Represented by two characters, the first character "tsu", means harbour, while the bottom character, "nami". means "wave."Tsunami is a series of large waves of extremely long wave length and period usually generated by a violent,mover undersea disturbance and activity near the coast or in the ocean (Ramy, 2005). Tsunami waves are mainly formed with the sudden displacement of seabed due to an underwater earthquakes. In the deep sea, it propagates with a high speed and small or low wave amplitude. A Tsunami travels outward from the source of the region as a series of waves another way say that, A tsunami is an incongruity sea level elevation seen some times as a series of water body waves with a long wavelength and period generated by a large, impulsive displacement of sea water. In the deep sea, it is propagate with high speed and the low wave amplitude. At the same time wave amplitude is rapidly increasing and converts in to killer waves and inundates low-lying coastal areas resulting mass destruction.

(1).When the tsunami waves reach shore, speed of the waves are decrease according to the topography of the sea bed level. One of the grate hazards due to tsunamis, even of small amplitudes, are the very strong currents that can be produced, that can rip the tie lines of vessels and cause risky damage to piers and docks (2).In order to reduce the clash of tsunami, it is beneficial to have a thorough imbibitaion of the area at risk , infrastructure,its population, , and the pattern of land use of study area. For anyone in tsunami evacuation zones, strong ground shaking from an earthquake is the natural warning that a tsunami might be coming. People on the beach or in harbour areas should evacuate for any felt earthquake and, if strong shaking lasts for 50 second or more, all the people within evacuation areas should move inland or to higher ground level. However, strong earthquake stir can also cause additional hazards, such as landslids. which can remain or prevent safe evacuation zone (3).Identification of those potential hazards along with evacuation routes, evacuees might be routed through areas where they could become injured while the moving away from potential of tsunami inundation area.The state tsunami program provides assistance to domains that request rescue with prepare or reviewing evacuation plans to address local-source of tsunamis (4). However, for local domain that would like to evaluate those potential evacuation hazards using their own resources, now the following step-by-step guidance is provided as below, A tsunami evacuation plan (TEP) is a plan that will be invoked if a tsunami alarm has been triggered. Hence a TEP will affect a variety of preparedness measures to be activated in the case of tsunami alert. The purpose of a TEP is to save the life of those persons that might be affected by the incoming or arriving of tsunami waves (5). Tsunamis may arrive at Gujarat shores within 40-60 minutes after the earthquake that has triggered at Makran zone . In some locations arrival times can be even shorter. It is vital that individuals, families and institutions have the capacity to react in a quick and appropriate manner to avoid the damaging waves and their impacts (6). Therefore,the local evacuation plans and warning arrangements are needed. To achieve this, it needs to involvement of many stakeholders, from local authorities to different elements in the communitys.

II. STUDY AREA

- The study area is porbandar city situated in wasten part of Gujarat.
- The city falls at the latitude 21.6300°N Longitude: 69.6000° E
- The coastal area of the porbandar city is 43.74 sq.kms
- The normal rainfall of the district is around 568 millimetres with variation from 290 mm to 900 mm in different parts of the district.

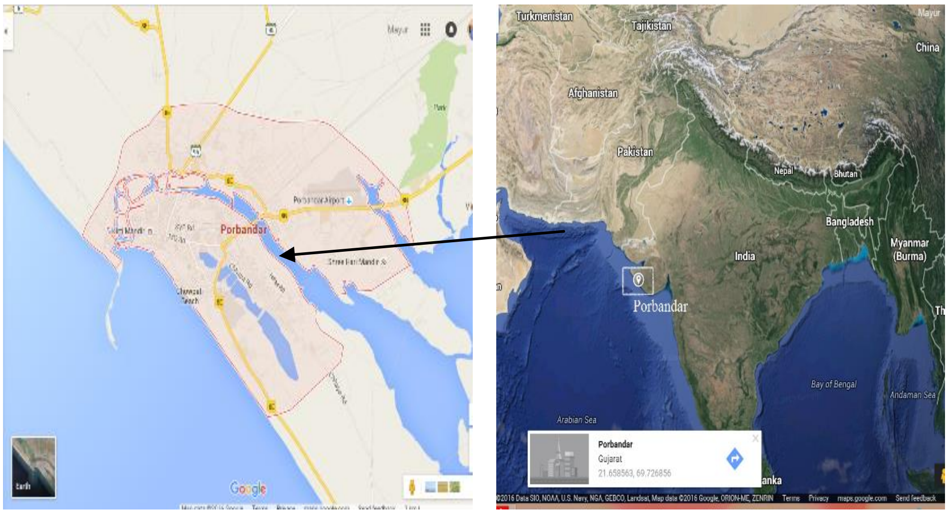


Fig 2 Location map of study area

POSSIBILITY OF TSUNAMI IN GUJARAT

A Five of the massive earthquakes in Makran zone may have ruptured the plate boundary in four different rupture segments of lengths of about 205 km each in 1483 (58–60°E), 1851 and also 1864 (61–63°E), 1945 (64–65°E), and 1765 (65–67°E) (7). Out of all these earthquakes only the 1945 earthquake was known to have caused a large tsunami, followed by a large aftershock in 1947 immediately to the south. The western Makran zone has no clear record of historic great earthquakes. Absence of frequent earthquakes indicates either that seismic subduction occurs or that the plate boundary is currently locked and experiences great earthquakes with long repeat periods (8).
One of the most deadly tsunamis ever recorded in the Arabian Sea occurred with its epicenter located in the offshore of Pansi in the northern Arabian Sea, about 100 km south of Churi (Baluchistan), Pakistan , at 21.56 UTC (03.26 IST) on November 28, 1945. More than 4000 people lost their life along the Makran coast of Pakistan by both the earthquake and tsunami. The tsunami was responsible for great loss of life and destruction along the coasts of India, Pakistan, Iran. The earthquake's Richter Magnitude (Ms) was 7.8 (Pendse, 1948) & the Moment Magnitude (Mw) was revaluated to be 8.1 (9).

Figure 1: Great Earthquakes in MSZ.(V.M Patel et. al., 2011)

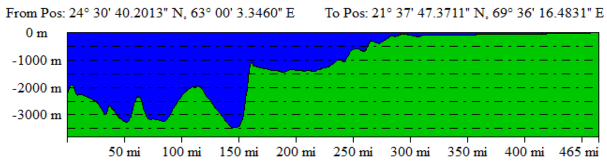
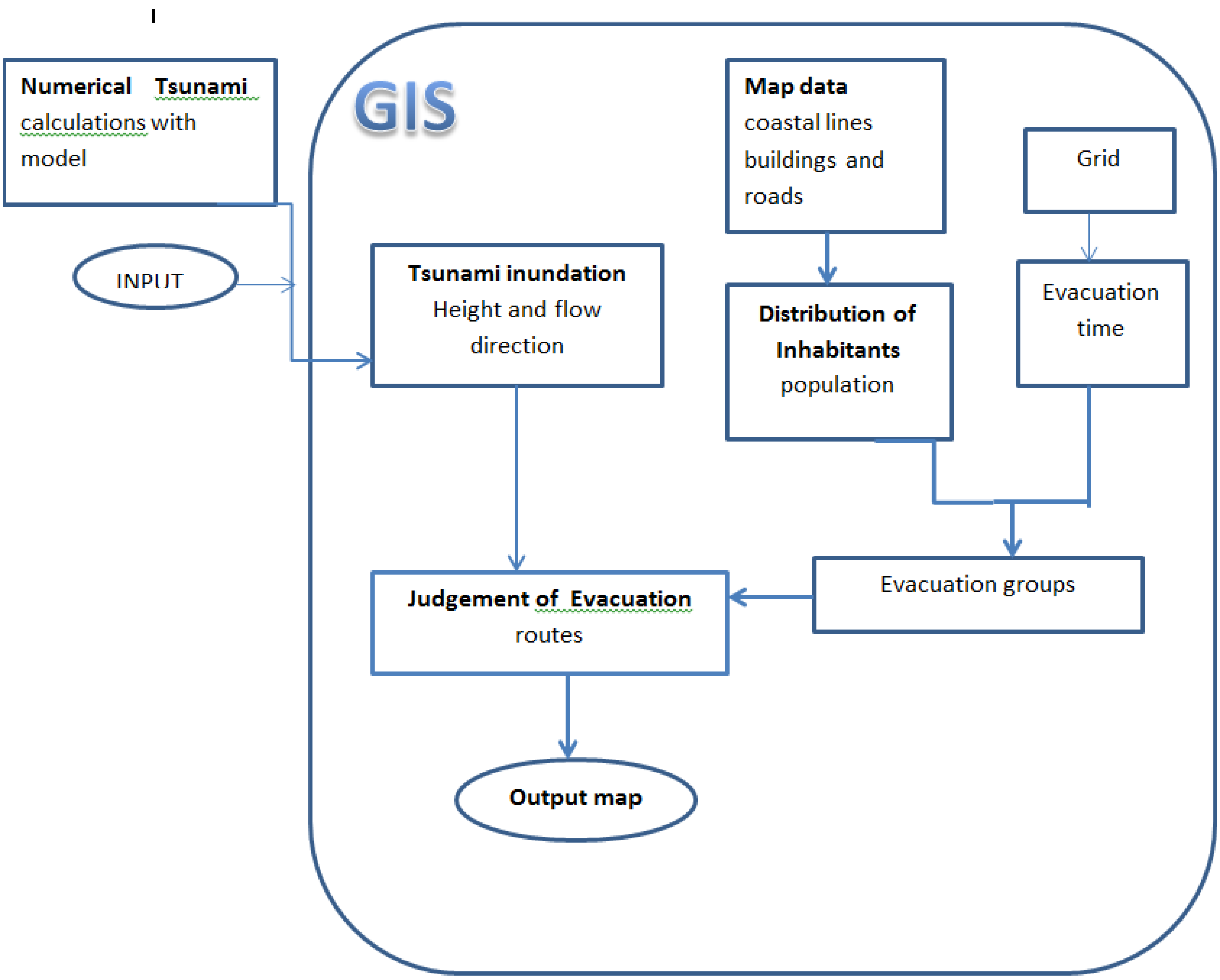


Figure 2: Makran Subduction Zone to porbandar City bathymetry profile

III. METHODOLOGY



Flow chat of methodology

The Step wise procedure of evacuation mapping is as following:

Step No 1: The mapping is stepwise process so that In mapping of tsunami first the satellite image showing population is geo-referenced with the SRTM data of Gujarat using software.

Step No 2: The contours are generated in the geo-referenced image. Than the coastal regions are shown using different colors and hazard map is prepared by showing 1 to 8 m heights by different colors.

Step No 3: The details of topography and colors indicated is shown in maps.

Step No 4: The evacuation maps are then prepared according to recommendations.

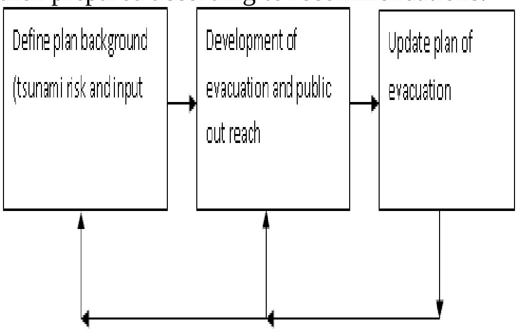


Figure 3: proposed methodology for Tsunami Evacuation Map

IV. RESULTS AND ANALYSIS

The image of porbandar city is shown in the sketch. The population density is assumed to be dense in densely populated area as shown in the satellite image. Various thematic maps are generated for parameters to be analysed. Figure 4 shows Road map of porbandar city, Figure 5 shows the Population map with existing routes of porbandar city, Figure 6 shows snap shot of Geo-reference map of porbandar city, Figure 7 shows snap shot of Hazard map of porbandar city and Figure 8 shows Snap shot of Evacuation map of porbandar city.

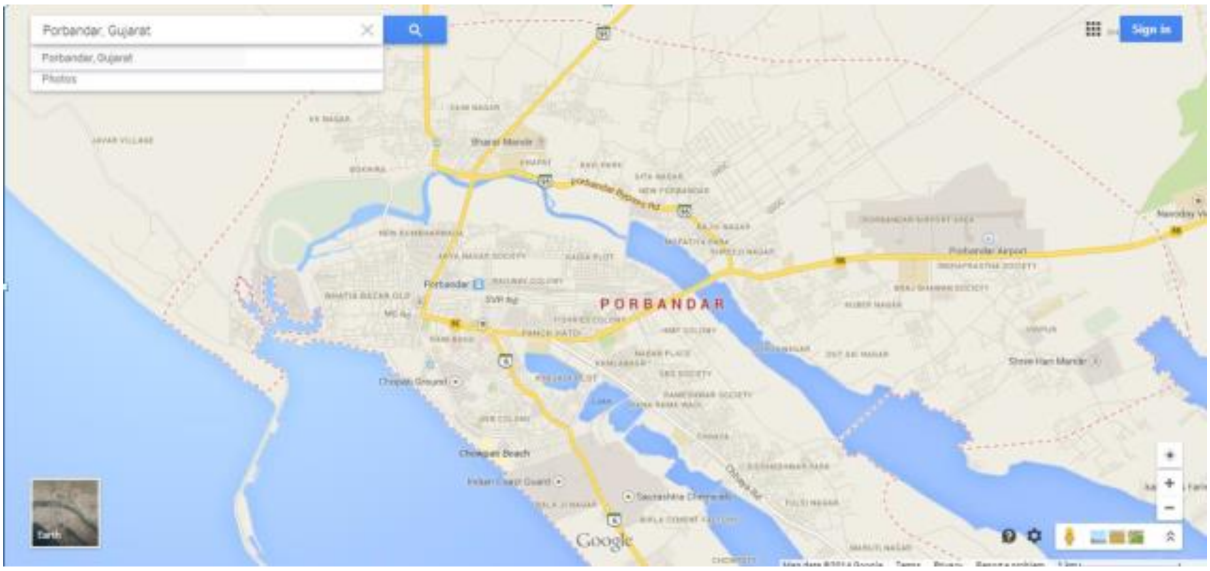


Figure 4: Road map of porbandar city

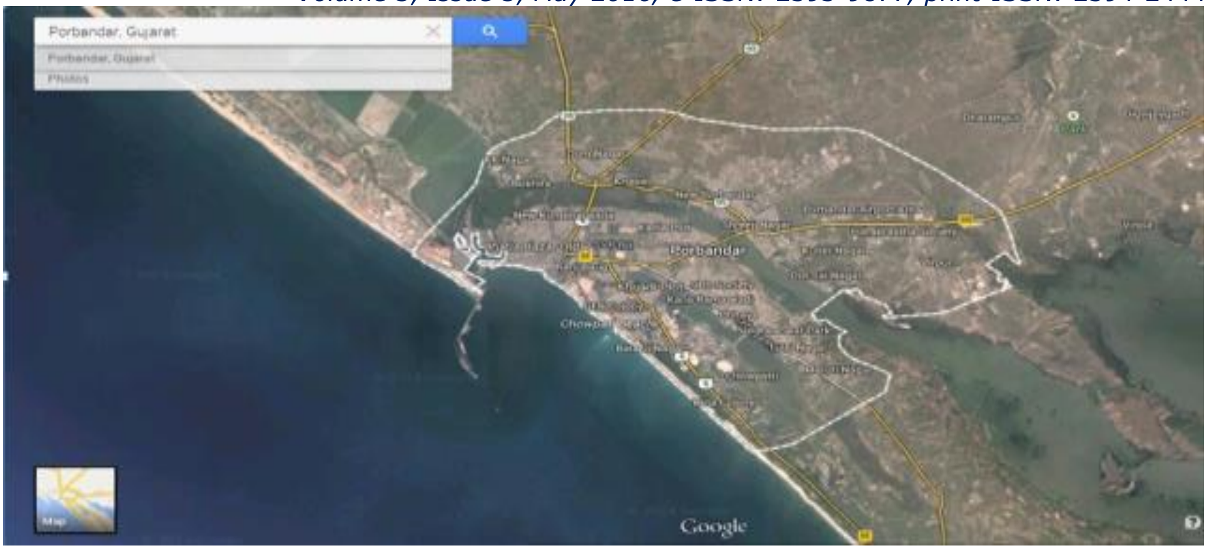


Figure 5: Population image with existing routes (Sources: Google Earth)

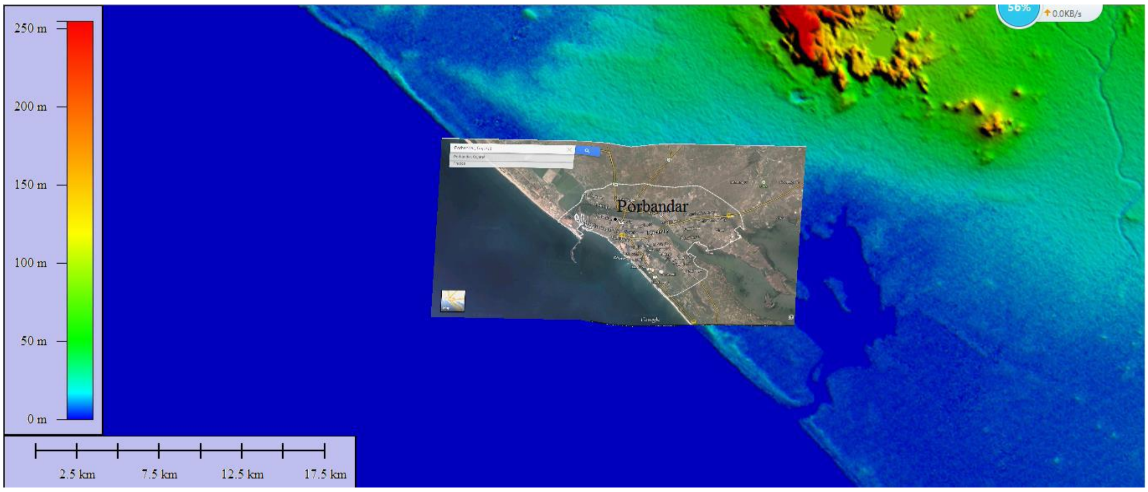


Figure 6: image of Geo-reference map of porbandar city

Figure 7:Image of Hazard map of porbandar city

HAZARD MAPS OF PORBANDAR CITY WITH RISE OF WATER LEVEL

Below shown in figures indicate the hazard risk due to rise in height of tides and for various levels of rise of sea water due to the same is successively shown in the figures for rise of water level starting from 2m up to 8m. For all the figures, the coloured zones in each map shows the safety zones while the zones falling in the white colour are the risk zones.

Image of 2D Tsunami risk model of Porbandar city for 2m height

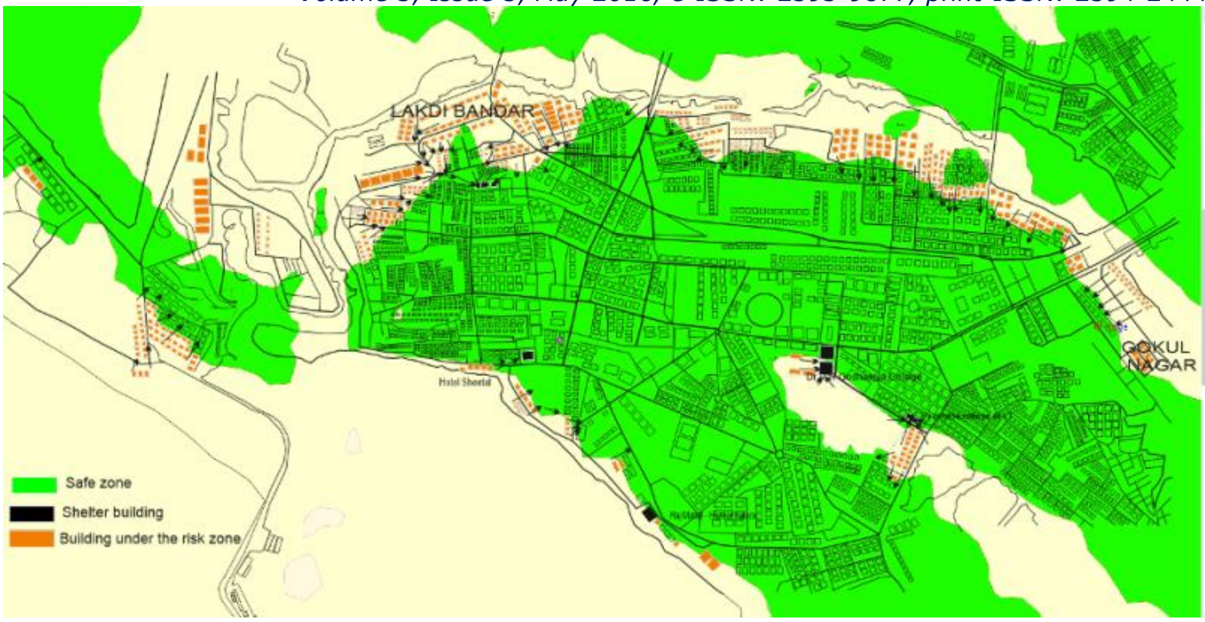


Image of 2D Tsunami risk model of Porbandar city for 4m height

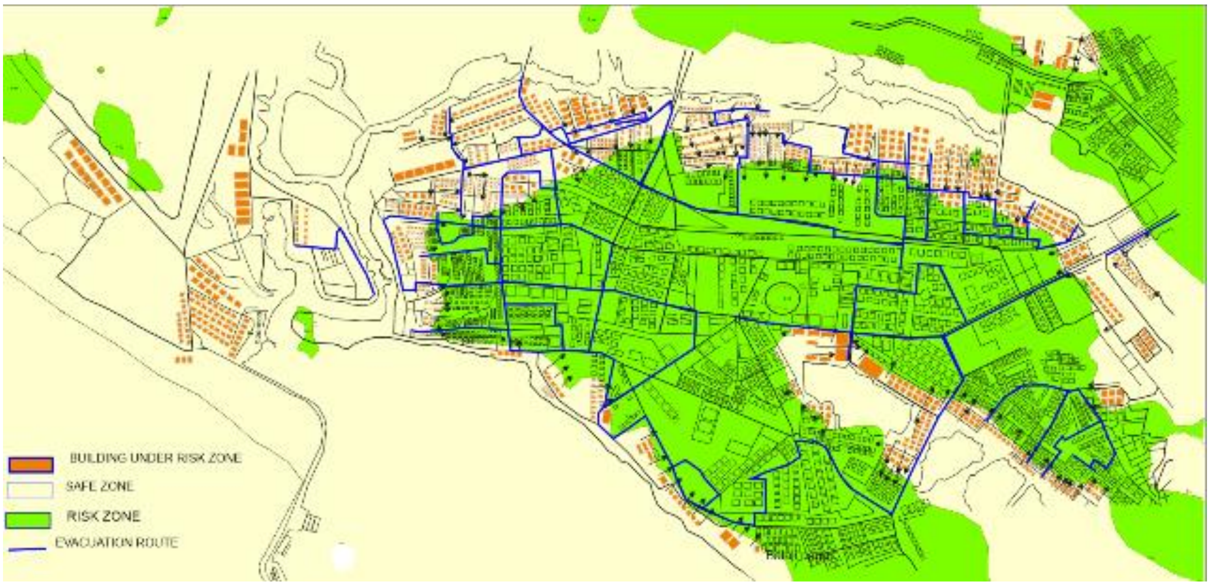


Image of 2D Tsunami risk model of porbandar city for 6m rise of water level due to tides

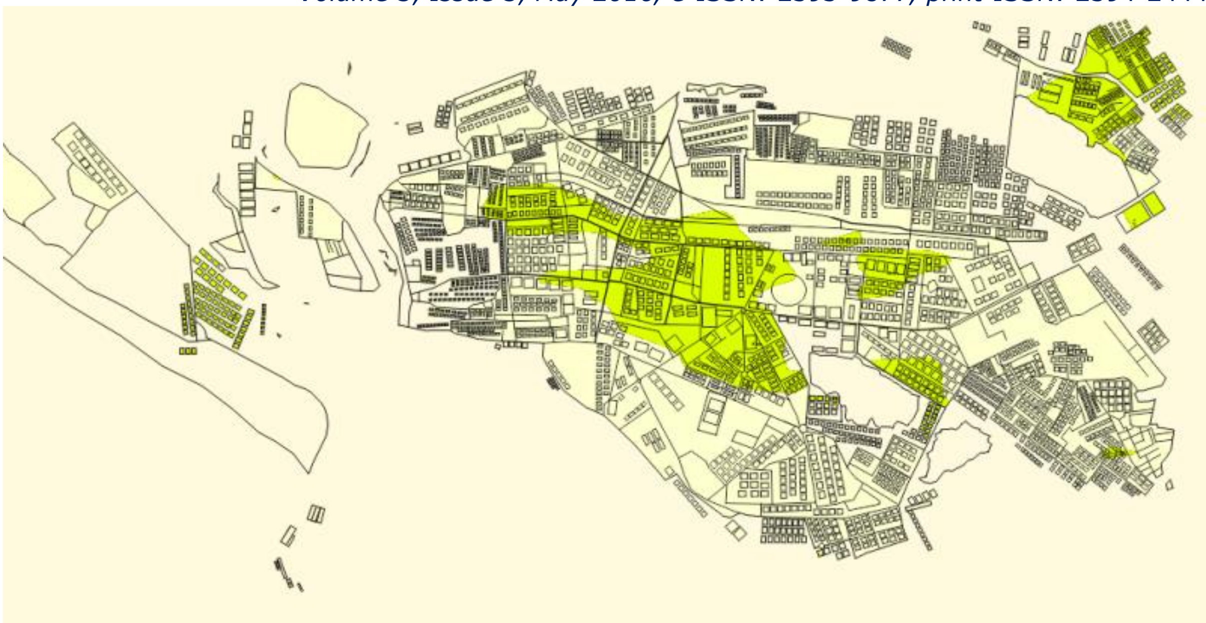


Image of 2D Tsunami risk model of porbandar city for 8m rise of water level due to tides

Figure 8: Image of Evacuation map of porbandar city

A vertical evacuation refuge from tsunamis is a building or earthen mound that has sufficient height to elevate evacuees above the level of tsunami inundation, and is designed and constructed with the strength and resiliency needed to resist the effects of tsunami waves. (FEMA P646).

Vertical evacuation structures can be intended for general use by the surrounding population, or by the occupants of a specific building or group of buildings. Choosing between various options available for vertical evacuation structures will depend on emergency response planning and needs of the community, the type of construction and use of the buildings in the immediate vicinity, and the project-specific financial situation of the state, municipality, local community, or private owner considering such a structure. (FEMAp646).

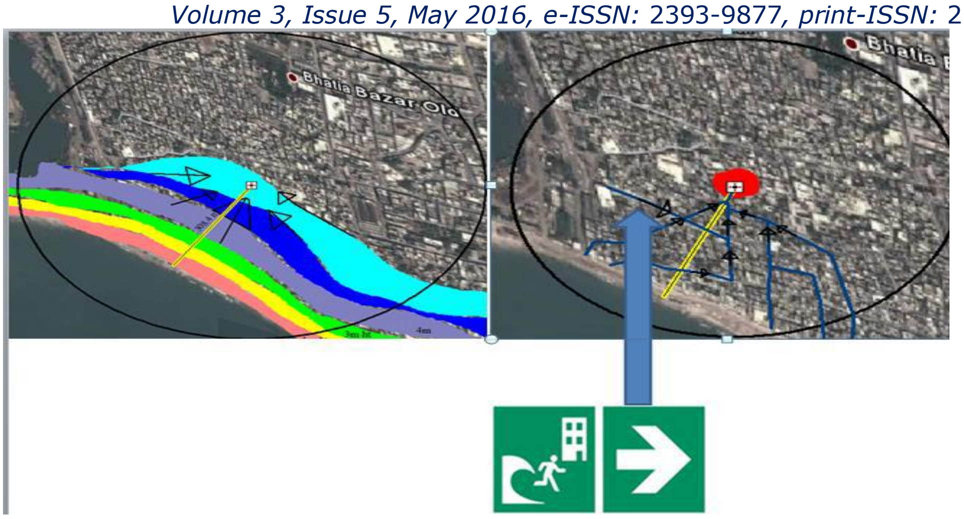


Figure 9: Vertical Evacuation Structures proposed at porbandar city

Modeling and Prediction

- Numerical modeling of tsunamis is commonly carried out to better understand events that have occurred either during or before historical times. The TUNAMIN2 model requires bathymetry and topography data for processing as input data. The data of bathymetry and topography is collected from Institute of Seismological Research, Gandhinagar. The details of Makaran Fault are collected.

- Study literature related to intended research work Create bathymetry with the help of GEBCO, GMB & SRTM data sets of Arabian Sea. Model propagation of tsunami waves using TUNAMI-N2 for Western coast of Gujarat for MSZ Evaluate tsunami evacuation alternatives

- Numerical modeling can also help to predict the effects of a future tsunami. Tsunamis which are mainly generated by the movement of sea bottom due to earthquakes belong to long waves. In the theory of such waves, the vertical acceleration of water particles are negligible compared to the gravitational acceleration except for an oceanic propagation of tsunami. The generation and propagation of tsunami waves are modeled using TUNAMIN2 code with the kind permission of Institute of Seismological Research, Gandhinagar. TUNAMI-N2 is authored by Fumihiko Imamura of Tahoku University, Japan, and developed in Middle East Technical University (METU) and in the University of Southern California. TUNAMI N2 uses this initial wave data to start with the modeling.

Fault length = 150 to 350 km , Width of the fault = 50 to 100 km , Focal Depth = 5 to 15 km , Angle between N & fault axis (strike)= 230 º to 270 º , Dip Angle = variable 10 º to 25 º, Displacement (Slip) = 8m to 12m
Simulation result of the western part of the MSZ indicates that the Tsunami wave reflected from Arabian Peninsula and Owen fracture zone (shallow bathymetry) sends energy towards southeast direction along the western coast of India that could cause devastation of loss of life in future. The Tsunami wave height around the coast of Pasni (Pakistan) was 0.8 m, Kachchh was 0.4 m and porbandar was 0.3 m respectively,so that in this paper the outcome of the modelling is directly used as a input of evacuation model.

V. CONCLUSIONS

Evacuation is the most important and effective method to save human lives during a tsunami. An important factor in establishing evacuation measures during a tsunami is an accurate representation of the timing of people's responses to the emergency. In this study, with the help of satellite technology or using image tsunami evacuation map is generated for western coast of porbandar city for Indian subcontinent. In this study evacuation map of study area is generated in an open source map digitalization tool. the hazard risk due to rise in height of tides and for various levels of rise of sea water due to the same is successively shown in the figures for rise of water level starting from 2m up to 8m.Vertical Evacuation Suggestions of study area are derived from further analysis of geo referenced map. These Vertical Evacuation Suggestions are provided based on various parameters related topography and geology of study area. These results of this study can be utilized by public policy and decision makers in developing disaster management strategies

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