GIS based analysis of Coastal Vulnerability Assessment for Chennai, Tamilnadu

S.Dineshkumar, G.Prabhakaran
M.Sc, Students, Department of Geology,
Alagappa Government Arts College, India

Abstract

As a significance of variation in worldwide climate, an improved occurrence of natural vulnerabilities like storm flows, tsunamis and tornadoes, is projected to have intense effects on the coastal societies and ecosystems by asset of the destruction they cause during and after their occurrence. The main natural disasters that occurred recently such as the tsunami, the Thane cyclone and the Vardha cyclone were caused widespread human and financial losses along the coastal areas of Tamil Nadu. The study area is coastal zone of Chennai districts of the Tamil Nadu state, southeast coast of India. The destruction caused by these happenings emphasized the need for susceptibility assessment to ensure better understanding of the features instigating different threats and to accordingly reduce the after- effects of the future actions. This paper determines a systematic hierarchical process based methodology to coastal vulnerability studies as development to the prevailing approaches for susceptibility assessment. The final consequences of this study are in the practice of a coastal liability map which demonstrates the ecologically vulnerable zones. This record will give common idea about the prospect of an area to endure coastal threats as a result of coastal destruction or sea level rise. Both predictable and remotely sensed data were used and evaluated through the exhibiting technique and with the benefit of the Remote Sensing and Geographic Information System (GIS) tools. Regions of vulnerability to littoral natural hazards of different level (high, medium, and low) are recognized.

Keywords: *coastal vulnerability assessment, Remote Sensing and Geographic Information System*

I. INTRODUCTION

Coastal Hazards are corporeal or natural occurrences that interpret a shoreline zone to hazard of property destruction, loss of presence and ecological declination. Temporary littoral hazards last over minutes to some days and examples comprise hurricanes, tsunami and storm surges. Enduring coastal hazards improve incrementally over extended time periods and illustrations include erosion and sea level rise and gradual accumulation. Marvelous population and progressive pressures have been erecting in the coastal areas for the last few decades. In light of the unbalanced climate change, the shore areas establish the most dynamic, yet susceptible, environments in the world.

These coastal bindings habitually demonstrate to be the hot spots of austere effects related with stable inundation of low-lying areas, augmented flooding due to risky weather events like storm surges and tsunamis, greater erosion rates affecting beaches and cliffs, and devastation due to calamities like cyclones. Due to diverse human pressures, many coastal areas are previously suffering serious environmental harms, such as coastal destruction, pollution, deprivation of dunes, and brackish interruption of coastal aquifers and rivers.

Indices have been established in the past so as to study instabilities associated to factors such as sea-level rise, wave erosion, human influences, and oil-spill effects. The detached of coastal indices is to categorize the shores into identical entities having similar structures. This arrangement can then help in the growth of sound coastal management strategies. To organize a wide-ranging coastal directory that is a true demonstration of the ground representativeness, useful, sound, and consistent data are a requirement.

There are frequent types of shore surroundings in India with very different structures that affect, impact, and change the proximate shore developments that are expanded. Accepting these environments and ecologies can grow for alleviating techniques and policy-making determinations against natural and anthropogenic coastline hazards in these vulnerable areas. The variations of coastal regions are forceful process, thus, regular observing of coastal zone is very significant. Additionally, planning of a proper coastal zone organization strategies along with application of principles in the coastal zone involve spatial information on the shore land use and land systems along with tidal region, the inventory and status of sea territories and information on economically Sensitive Areas.

Remote sensing techniques have been extensively used for evaluating, observing and management of natural resources in the shoreline areas. As a result of its tedious, multispectral and synoptic nature, satellite Remote Sensing has demonstrated to be enormously useful in providing information on various features of the coastal atmosphere, viz. littoral landforms, seashore changes, tidal levels, early tsunami cautions, weather predicting, deferred residue subtleties, coastal streams, dynamic coastal homes, etc.

Susceptibility may be defined as a core risk factor of the issue or system that is uncovered to a hazard and resembles to its intrinsic tendency to be exaggerated, or to be vulnerable to damage. In common, the concept of hazard is now used to mention to a concealed danger or a peripheral risk factor of a system or visible subject. This can be in accurate form as the possibility of occurrence of an event of certain intensity in a particular site and during an unwavering period of coverage. Instead of, vulnerability may be assumed, in common terms, as an internal risk aspect that is statistically stated as the possibility that the uncovered subject or system may be exaggerated by the occurrence that exemplifies the threat. Thus, possibility is the impending loss to the exposed subject or system ensuing from the obscurity of hazard and vulnerability. In this logic, risk may be articulated in a scientific formulas the possibility of outstanding an indomitable level of economic, public, or environmental significance at a definite site and during an assured period.

II. STUDY AREA

Chennai is situated on the north-east end of Tamil Nadu on the coast of Bay of Bengal. It lies between 12* 9' and 13* 9' of the northern latitude and 80* 12' and 80*19' of the southern longitude on a `sandy shelving breaker swept beach'. The study area is 56 km coastal zone covering Chennai districts of the Tamil Nadu state along the southeast coast of India. It stretches nearly 25.60 kms along the Bay coast from Thiruvanmiyur in the south to Thiruvottiyur in the north and runs inland in a rugged semi-circular fashion.

It is bounded on the east by the Bay of Bengal and on the remaining three sides by Chengalpattu and Thiruvallur Districts. Chennai with current population of 8,233,084 (8.2 million) is one of the largest cities of South India. The city is intersected by two languid streams, the Cooum and the Adyar. The river receives a sizeable quantity of sewage from its neighborhood for disposal. Though the river Adyar can be traced to a point near village, it assumes the appearance of a stream only after it receives the surplus water from the Chembarambakkam tank as wells as the drainage of the areas in the south-west of Chennai.

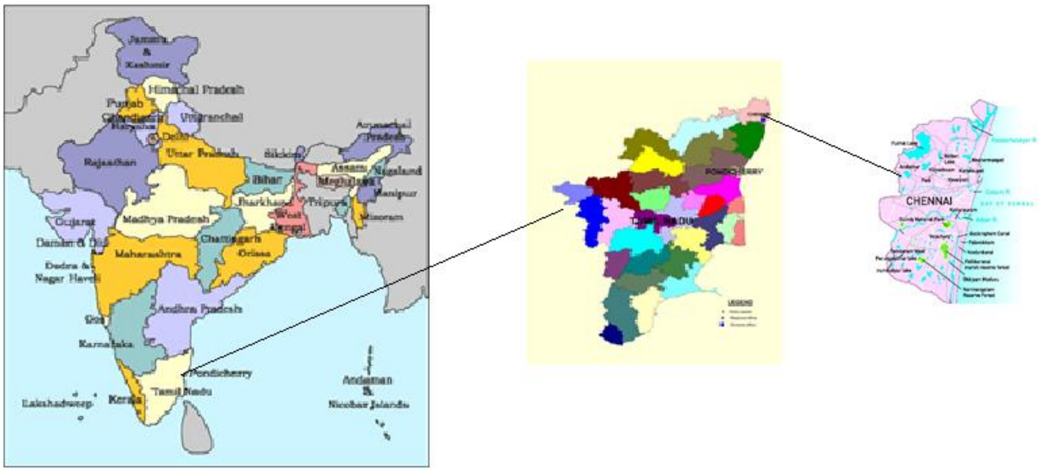

Fig.1: Study Area: Coastal Areas of Chennai, Tamilnadu

III. MATERIALS AND METHODS

According to previous proposed systems, susceptibility to climate change is the unit to which geophysical, biological and socio-economic systems are vulnerable to, impotent to manage with, hostile influences of climate change. Exposure valuations should alter their concentration from quantifying the liability of a place to rather assessing the vulnerability of selected restrictions of concern and to specific sets. From this viewpoint, the qualified exposure of the different littoral environments to natural threats can be considered using information concerning to various physical along with geological features of the coastline as an input to evaluate the physical vulnerability index (PVI).This permits the eight variables to be associated in a assessable manner that articulates the relative vulnerability of the coast to somatic changes owing to future sea level rise. This method earns numerical data that cannot be equated directly with specific physical effects. The major relative risk variables used are shoreline change rate, sea-level change rate, coastal slope, mean significant wave height, mean tidal range, coastal regional elevation, coastal geomorphology, and tsunami run up. Most of these factors are vibrant in nature and needs large amount of data from different causes to be attained, evaluated, and treated. They are resultant from remote sensing, GIS, and numerical model data.

A. Shoreline Change Rate

Coastal areas are continuously exposed to changes owing to shoreline developments, which are organized by wave features and the resulting near-shore movement, deposit features, beach form, etc. From the coastline exposure point of view, coasts imperiled to mass will be considered as less vulnerable areas as they move near the marine and result in the accumulation of land areas, however areas of sea erosion will be considered as more susceptible because of the subsequent loss of reserved and communal property and essential natural habitats such as beaches, sandbanks, and wetlands. It also decreases the distance between coastal inhabitants and ocean, thus increasing the risk of acquaintance of population to coastal hazards.

B. Sea-Level Change Rate

Sea-level rise is a vital significance of climate change, both for people and for thesurroundings. Mean sea level at the coast is demarcated as the height of the sea with detail to a local land target, be close to over a period, such as a month or a yearlong sufficient that variations caused by waves and tides are largely detached. Variations in mean sea level as restrained by coastal tide estimates are called qualified sea-level changes. Sea-level rise can be a product of global warming through two main practices: thermal expansion of seawater and extensive melting of land ice. Global warming is projected to cause substantial rises in sea level over the course of the twenty-first century. Thus it turns out to be essential to study the effect of sea-level rise on the coastal areas.

C. Coastal Slope

Coastal Slope is used to define the measurement of the sharpness, incline, gradient, or status of a straight line. A greater slope value specifies a vertical slope and vice versa. The coastal slope is defined as the fraction of the altitude change to the horizontal distance between any two points on the coast. It is related to the vulnerability of a coast to blizzard by flooding. The run-up of waves on a coast is the most significant period of a tsunami from the perspective of assessment of the levelof tsunami threat for the coast. The required characteristic is an essential parameter in determining the degree to which coastal land is at risk of flooding from storm floodsand during a tsunami. Seasidepositions having gentle land slope values have great infiltrationof seawater associated with locations with smaller amount slopes, and ensuing land loss from accumulation is merely a function of slope: the lower the slope, the greater the land loss.

D. Significant Wave Height

Important wave height is the typical height (trench to apex) of the one-third highest waves valid for the specified half a day period. Mean important wave height is used here as a delegation for wave energy, which initiates coastal deposit convey. Wave energy rises as the square of the wave height; thus the capability to establish and carriage beach/coastal materials is a function of wave height. By means ofextending directional wave rider buoy, wave height data recorded byscientists of National Institute of Oceanography (NIO), was utilized to estimate significant wave height. In general, wave heights are measured to demarcate the susceptibility line all along the shore. Wave energy increases as the square of the wave height; thus the ability to assemble and transport beach/coastal materials is a function of wave height. Those coastal areas of high wave height are considered as more susceptible coasts and areas of low wave height as less susceptible coasts.

E. Tidal Range

Required by the gravitational pull of the moon and the sun, tides are intermittent and highly expectable. Tidal range is the erect difference between the highest high tide and the lowest low tide. Tidal range is related to both everlasting and occasional inundation threats. From the susceptibility point of view, it is clearthat the tendency to entitle coastal areas of high tidal range as extremely susceptible. This assessment was based on the model that large tidal range is related with strong tidal streams that influence coastal behavior. For the recent study, shoreline areas with high tidal range are deliberated as high vulnerable and low tidal range as low vulnerable.

F. Coastal Regional Elevation

Coastal local elevation is raised to as the standard altitude of a explicit area above mean sea level. It is significant to study the coastal regional elevation aspect for the study area to distinguish and assess the extent of land area vulnerable by future sea-level rise. These coastal elevation data are also used to assess the land possibly available for wetland relocation in reaction to sea-level rise and the sea-level rise influences to the human built surroundings. From the shore susceptibility point of view, coastal regions consuming high elevation will be deliberated as less vulnerable areas because they deliver more resistance for accretion in contradiction of the rising sea level, tsunami run-up, and tempest surge. Those seashore regions having low elevation are considered as highly vulnerable areas.

G. Coastal geomorphology

The geomorphology supple articulates the relative corroding of different landform types. The word coastal susceptibility as used in this study refers to the possibility of being attacked of coastal landforms to risks such as wave attrition, tsunami, and storm surge flooding, etc. Most erodible feature signifies most risk and is most susceptible; however, least corroded feature denotes lowest risk and is smallest amount of vulnerable. The north coastal extension of Chennai city is conquered by more susceptible and delicate geomorphic features like flood plain, deltaic plain, salt flat, water bodies, sand shorelines and mud planes etc. However, in the central and southern coastal stretch, geomorphic features are covered by residential and industrial area beach sands, sand dunes, and beach ridges along coastal zone.

H. Tsunami run up

Tsunamis effect in production of waves of different phases and height. These wave factors depend on earthquake source restrictions, bathymetry, beach synopsis, coastal land topography, and occurrence of coastal configurations. These streams cause flooding of seawater into the land as much as 1 km or even more, ensuing in loss of human life and obliteration to property. The Indo–Burma–Sumatra zone is known to generate large oceanic earthquakes that are proficient of creating tsunamis in the Indian Ocean.The seismic deformation for an earthquake has been calculated using the earthquake factors like position, focal seriousness, attack, dip and rake approaches, length, width, and slip of the responsibility plane. Based on the run-up conventional along the entire study area, the risk ratings are assigned.

IV. COASTAL VULNERABILITY INDEX

The certain parameters are divided five classes based on the susceptibility from very low to very high. The value permits the seven variables to be associated in an assessable manner that articulates the qualified vulnerability of the coast to corporal changes as a result of future sea-level rise. This technique profits numerical data that cannot be connected directly with specific physical effects. It does, nevertheless, focus areas where the different effects of sea-level rise may be the highest. As soon as each sector of seashore is allotted a vulnerability value for each specific data variable, the coastal vulnerability index (CVI) is intended as the square root of the product of the ranked variables divided by the total number of variables as.

$$CV1 = \sqrt{(a*b*c*d*e*f*g)/7}$$

Where,

a=shoreline erosion/accretion rate

b=coastal slope

c=coastal regional Elevation

d=Mean sea-level rise

e=mean tide range

f=mean wave height

g=geomorphology

The preferences offered for the security of the Chennai coast from future shoreline hazards could be ridge afforestation, mangrove restoration and management, intermittent beach nutrition and building embankments and breakwaters. The construction of embankments is to be limited only for some settlements that are at high risk of accumulation. The combined coastal zone administration plan is still not fully in practical. It must accentuate more on building parameter, urban growth development, expansion of recognized capacity, contribution of local community, aggregating public attentiveness and should be based on long-term bearable progressive programs.

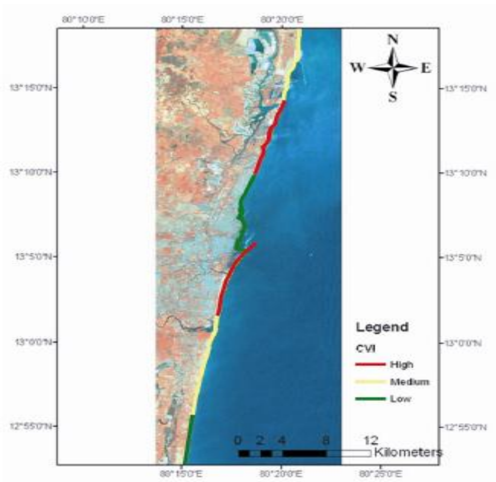

Fig.2: Coastal Vulnerability Index

V. CONCLUSION

Data and techniques used in this study provide useful insight in assessing the coastal vulnerability and morphological changes in the coastal environs of the study area due to climatic changes, mostly by sea level rise and shoreline erosion. The coastal vulnerability maps produced using this technique serve as a broad indicator of threats to people living in coastal zones. The sea level rise and tides are more controlling to vulnerability than other parameters. This is an objective methodology to characterize the risk associated with coastal hazards and can be effectively used by coastal managers and supervisors for better planning to alleviate the losses due to hazards as well as for prioritization of areas for evacuation during disasters.

Table.1: Different Parameters of the Risk Variables

Sl. no	Parameters	Length (km)		
		Low	Medium	High
1	Shoreline change rate	223	183	52
2	Sea-Level Change Rate	0	430	0
3	Coastal Slope	18	172	276
4	Significant Wave Height	121	272	29
5	Tidal Range	87	161	183
6	Coastal Regional Elevation	5	35	367
7	Coastal geomorphology	22	287	83
8	Tsunami run up	28	64	237
9	Coastal vulnerability index	65	284	87

REFERENCES

[1] Kumar TS, Mahendra RS, Nayak S, Radhakrishnan K and Sahu KC (2010) Coastal vulnerability assessment for Orissa State, east coast of India. J CoasRes 26: 523–534.

[2] Allen, K.: Vulnerability reduction and the community-based approach, in: Natural Disasters and Development in a GlobalisingWorld, edited by: Pelling, M., Routledge (Taylor & Francis), UK, Canada and USA, 170–184, 2003.

[3] Peltier, W. R.: Global Isostatic Adjustment and Modern Instrumental Records of Relative Sea Level History, in: Sea Level Rise – History and Consequences, edited by: Douglas, B. C., Kearney,

[4] M. S., and Leatherman, S. P., Academic Press, 65 95, 2001.

[5] Yin, J., Yin, Z., Wang, J., andXu, S.: National assessment of coastal vulnerability to sea-level rise for the Chinese coast, J. Coast Conservation, 123–133, 2012.

[6] Mahendra, R. S., Mohanty, P. C., Bisoyi, H., Kumar, T. S., and Nayak, S.: Assessment and management of coastal multi-hazard vulnerability along the Cuddalore–Villupuram, east coast of India using geospatial techniques, Ocean Coast. Manage, 54, 302– 311, 2011.

[7] Phukon, P., Chetia, D., and Das, P.: Landslide Susceptibility Assessment in the Guwahati City, Assam using Analytic Hierarchy Process (AHP) and Geographic Information System (GIS), Int. J. Comput. Appl.Eng. Sci, 2, 1–6, 2012.

[8] Dinesh Kumar, P. K.: Potential Vulnerability Implications Of Sea Level Rise For The Coastal Zones Of Cochin, Southwest Coast Of India, Environ. Monit. Assess, 123, 333–344, 2006.

[9] Hanson, S., Nicholls, R., Ranger, N.,Hallegatte, S., Corfee-Morlot, J., Herweijer, C., and Chateau, J.: A global ranking of port cities with high exposure to climate extremes, Climatic Change, 104, 89–111, 2011.

[10] Jayakumar, S., Ilangovan, D., Naik, K. A., Gowthaman, R., Tirodkar, G., Naik, G. N., Ganesan, P., ManiMurali, R., Michael, G. S., Ramana, M. V., and Bhattacharya, G. C.: Run-up and inundation limits along southeast coast of India during the 26 December 2004 Indian Ocean tsunami, Curr.Sci, 88, 1741–1743, 2005.

[11] Warakish, G. S., Vinay, S. A., Natesan, U., Asano, T., Kakinuma, T., Venkataramana, K., Pai, B. J., and Babita, M. K.: Coastal vulnerability assessment of the future sea level rise in Udupi coastal zone of Karnataka state , west coast of India, Ocean Coast. Manage, 52,467–478, 2009.

[12] Cooper, J. A. G. and McKenna, J.: Social justice in coastal erosion management: The temporal and spatial dimensions, Geoforum, 39, 294–306, 2008.

[13] Mani Murali, R., Vethamony, P., Saran, A. K., and JayaKumar, S.: Change detection studies in coastal zone features of Goa, India by remote sensing, Curr.Sci., 91, 816–820, 2006.

[14] Szlafsztien, C. F.: Climate change, Sea-level rise and Coastal NaturalHazard: A GIS-Based Vulnerability Assessment, State ofPará, Brazil, J. Coast. Conserv., 11, 53–66, 2005.