

4. RESULTS

The CVI assessment has been carried out at state level because of the large variations in the range of the data values of individual parameters across the states, thus the CVI assessment on a national level may suppress the vulnerability in some states. Hence in view of extracting finer indices it is reasonably good to assess the CVI at state levels. This indicates that the CVI classes were comparable within the state. The results for each state are discussed in the following section.

4.1 Gujarat

Gujarat is situated on the west coast of India. The geographical constrain of the state are latitude from 20.1 N to 24.72 N and longitude 68.18 E to 74.5 E. Gujarat has an area of 75,686 sq mi (196,077 sq. km) with the longest coastline as compared to other coastal states. It is dotted with 41 ports (one major, 11 intermediate and 29 minor ports). Out of 25 administrative districts of the state, there are nine coastal districts. The total population of Gujarat state is 60.38 million with an average density of 308 people/sq. km . The densest district is Surat. The population of Daman and Diu (Union Territory) is 0.24 million with a density of 2,169 people/sq. km.

The CVI for Gujarat was estimated using the selected seven parameters (Table 3). The coastline of 2308 km comprising open coast, creeks and small islands were selected for the study. It was observed that the large coastal stretches are under low elevation with gentle slope. A total coastline of 1220 km and 1234 km were recorded under very high risk category by coastal slope and elevation respectively. Similarly the tidal range also contributed towards high risk. The Gujarat coast falls under a macro-tidal environment with tidal amplitude varying between 3 to 11 m. The major coastal geomorphology classes in the Gujarat state are: mudflats, coastal plains deltas and beaches. Few stretches of shorelines were found to be too dynamic due to frequent erosion and sedimentation along the gulf of Kachchh and Khambhat. Maximum sea level rise was observed along the coasts of the Gulf of Khambhat.

Table 3 Rank versus length of parameters along Gujarat Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	797	616	428	180	287
Coastal Slope	11	24	206	848	1220
Elevation	41	52	164	817	1234
Geomorphology	136	971	191	489	522
Sea level Change Rate	1284	84	112	84	745
Mean Significant Wave Height	174	864	539	383	349
Tidal Range	--	250	753	120	1185

Table 4 Statistics of CVI along Gujarat

CVI	Length (km)	% of Length
Low	984	42.61
Medium	1060	45.91
High	141	6.12
Very High	124	5.36
Total	2308	100.00

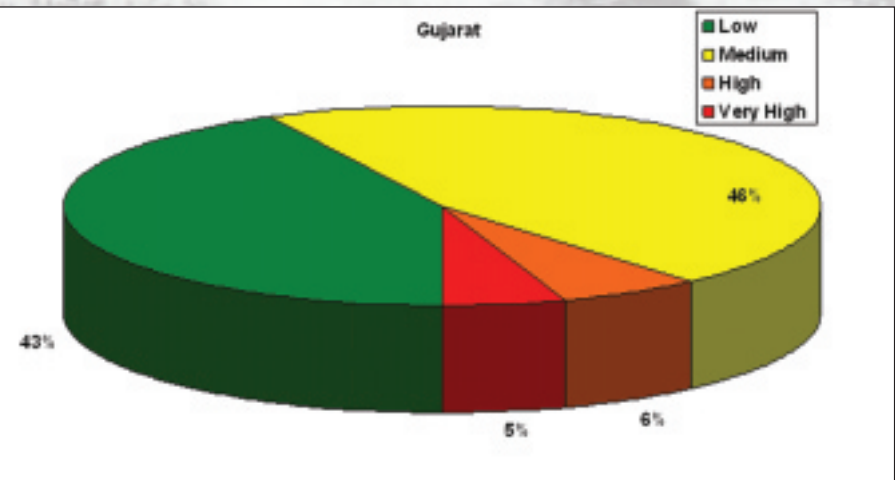


Figure 2 Pie chart is depicting the statistics of CVI classes of Gujarat



Figure 3 CVI map of Gujarat

The CVI assessment for the Gujarat coast indicates that 5.36% of the coastline is Very Highly Vulnerable with a total length of 124 km along the southeast coast, Gulf of Khambat and Gulf of Kachchh. The High Vulnerable Class constituted 6.12% of coastline (~141 km), Medium Vulnerability Class constituted 45.91% corresponding to a length of 1060 km and Low Vulnerable Class was the rest (42.61%) with 984 km (Table 4 and Figure 2). The map representing spatial distribution of the CVI classes along the Gujarat coast is shown in the Figure 3. High to very high vulnerability classes were observed along the coastal parts of Kachchh, Jamnagar, Amreli, Bhavanagar, Baruch, Surat, Navsari and Valsad districts. Porbandar and Junagadh districts were recorded predominantly medium and low vulnerability respectively. The coastal stretches in the northern parts of the Kachchh district are also depicted low vulnerability.

4.2 Maharashtra

Maharashtra is located on the western coast of the country covering a large area of 3, 07,690 sq. km. The state is second largest in terms of population (census of India 2011). The geographic extents of the state are between latitude 15.58 N to 22.03 N and longitude 72.60 E to 80.90 E. Mumbai is the capital of Maharashtra and the sixth largest metropolitan area in the world. There are 35 districts in Maharashtra, out of which five are coastal districts, viz. Thane, Mumbai (Suburban), Raigarh, Ratnagiri, and Sindhudurg. The total population of the state is 112.3 million with a density 365 people/sq. km. The total population of the coastal districts is 28.62 million, accounting to 25% of the total population of the state. Average population density of these districts is 7,141 people per sq km. The Mumbai (Suburban) district has a population density of 20,925 people per sq km, so overall the population along the coast can be considered as significantly high.

The CVI analysis indicates that large extent of the state is under High Risk (see Table 5) primarily due to coastal geomorphology (606 km), while coastal slope and elevation contributes towards 387 km and 389 km respectively. The coastal geomorphology of the state consists of sandy beaches, coastal plains, cliffs, spits, estuaries, etc. The Shoreline change rate factor indicates that the coastal stretches of Maharashtra experiences accretion with no significant change, thus the risk rating is Very Low.

The CVI analysis of the state reveals that a total coastline of length 434 km was classified as Low Vulnerable (~46.19 %). The length of Medium and High Vulnerability classes were 397 km and 97 km respectively (accounting for 42.25% and 10.34 % respectively). The length of Very High Vulnerability class was 11 km (~1.22 %) (See Figure 4 and Table 6). The map representing the spatial distribution of the CVI classes along the coasts of the Maharashtra state is shown in Figure 5. The Very High Vulnerable class was observed along the coast of the northern parts of the state from the Thane and Mumbai Suburban districts.

Table 5 Rank versus length of parameters along Maharashtra Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	306	333	208	53	39
Coastal Slope	21	89	139	303	387
Elevation	104	41	112	295	389
Geomorphology	51	79	121	82	606
Sea level Change Rate	742	66	44	40	49
Mean Significant Wave Height	98	113	129	206	394
Tidal Range	236	196	260	176	70

Table 6 Statistics of CVI along Maharashtra

CVI	Length (km)	% of Length
Low	434	46.19
Medium	397	42.25
High	97	10.34
Very High	11	1.22
Total	940	100.00

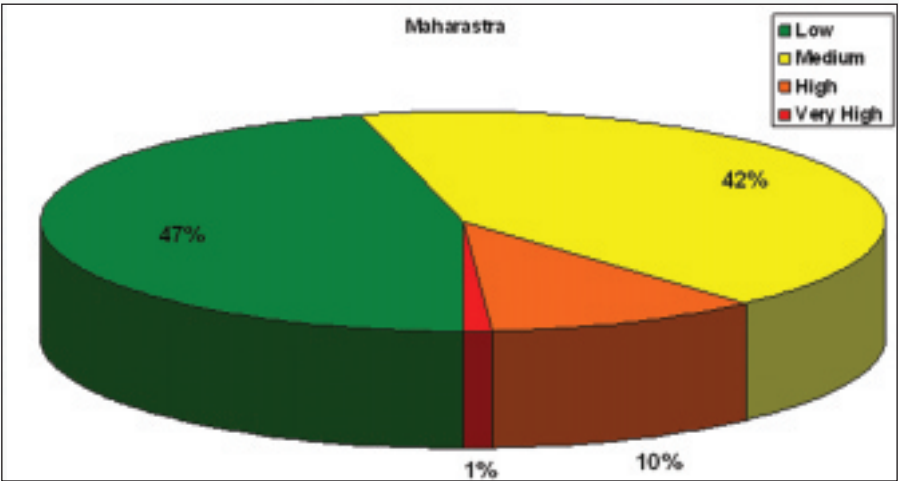


Figure 4 Pie chart is depicting the statistics of CVI classes of Maharashtra

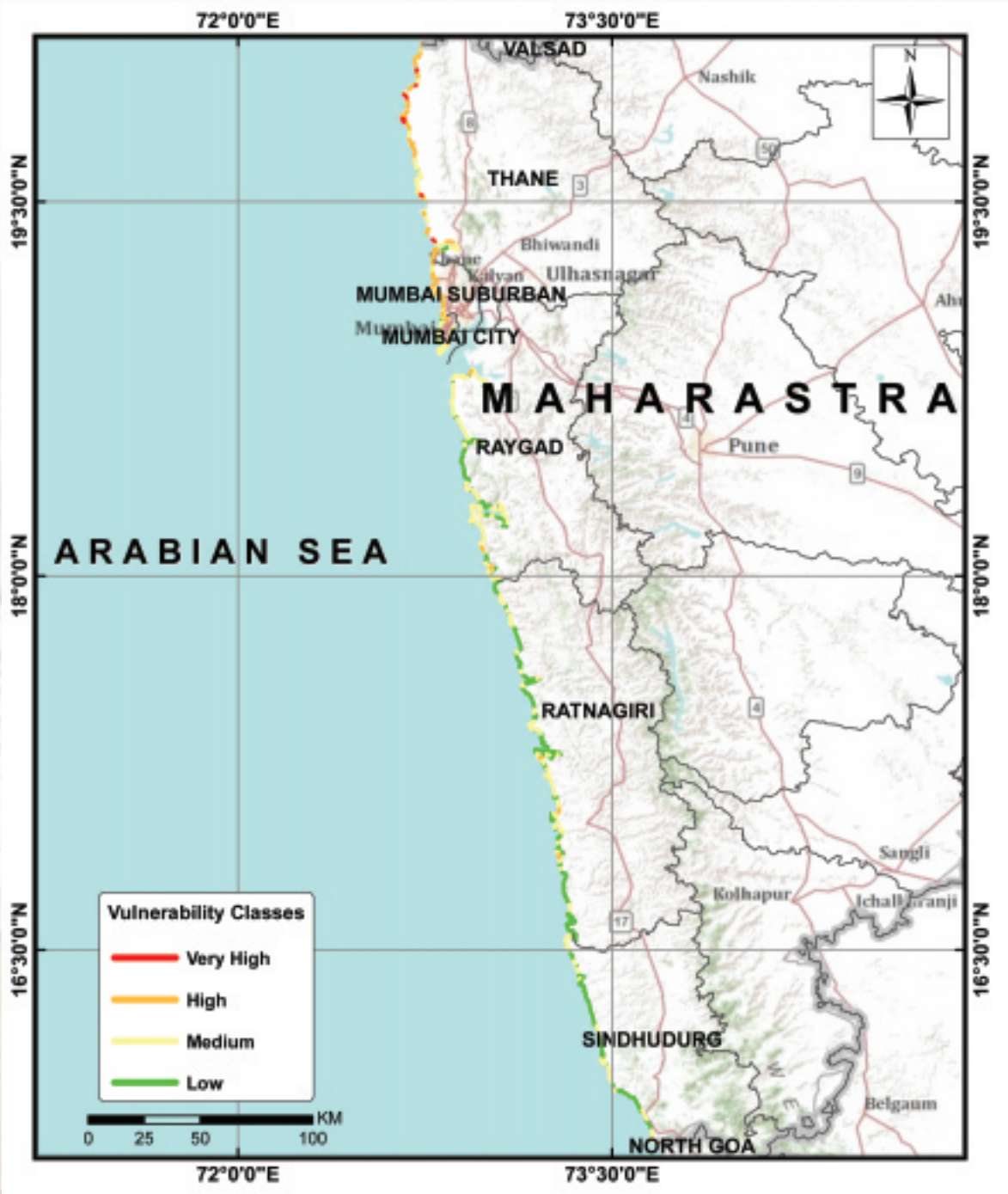


Figure 5 CVI map of Maharashtra

4.3 Karnataka and Goa

The states of Karnataka and Goa are located at Western Central part of India. The geographical constrains of Goa is latitude 14.90 N and 15.67 N and longitudes 73.67 E and 74.34 E and Karnataka is located between 11.50 N to 18.50 N latitudes and 74.00 E to 78.50 E longitudes. Karnataka and Goa are bounded by Arabian Sea to the west, Maharashtra in the North, Kerala and Tamil Nadu to the south and Andhra Pradesh in the east. The coastline of Karnataka extends over a length of 320 km. It is one of the most indented shoreline with numerous river mouths, lagoons, bays, creeks, promontories, cliffs, spits, sand dunes and long beaches. There are three coastal districts Uttara Kannada, Udupi and Dakshina Kannada having a population of 4.7 million and of population density of 250 people/ sq. km.

Goa has a land area of about 3,702 sq. km with a coastline of 101 km (63 miles). Goa state is divided into two districts namely, South Goa and North Goa. Both the districts border the Arabian Sea to the west. The population of the State is 1.46 million and is distributed in both the coastal districts with a density of 394 people per sq. km .

The results from the CVI analysis for the state of Karnataka and Goa are tabulated in Table 7. The shoreline change rates were observed to be in the range of 7 m/y erosion (-) to 8 m/y accretion (+). Because of the topography and geomorphology of the region, accretion process can be seen as more dominant. The wave activity in the state was slightly higher when compared to the Maharashtra state. The tidal range was observed to be between 1.6 to 2.5 m. The major geomorphic classes in this region are: sandy beaches, pocket beaches, low to high cliffs, and coastal plains.

Table 7 Rank versus length of parameters along Karnataka and Goa Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	189	78	77	58	100
Coastal Slope	25	16	43	138	280
Coastal Elevation	68	12	37	196	190
Geomorphology	131	85	22	–	265
Sea level Change Rate	174	165	47	52	66
Mean Significant Wave Height	61	63	55	103	220
Tidal Range	172	30	38	174	88

The results from the CVI analysis reveal that a total of 8 km coastal stretch is under Very High Vulnerability, which contributes to 1.61% of the total coastal length; whereas, large extent of the coastline can be classified as Low Vulnerable recording a length of 287 km (~57.09 %). The Medium and High Vulnerable classes recorded 160 km and 48 km accounting for 31.76 % and 9.54 % respectively (see Table 8 and Figure 6). The CVI map of these two states (shown in Figure 7) show Very High Vulnerable classes in parts of North Goa, South Goa and Uttara Kannada districts.

Table 8 Statistics of CVI along Karnataka and Goa

CVI	Length (km)	% of Length
Low	287	57.09
Medium	160	31.76
High	48	9.54
Very High	8	1.61
Total	503	100.00

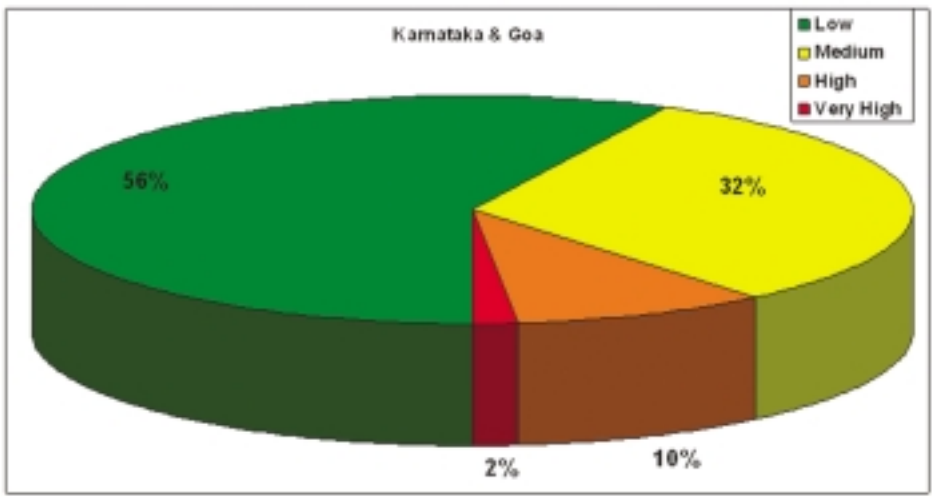


Figure 6 Pie chart is depicting the statistics of CVI classes of Karnataka and Goa

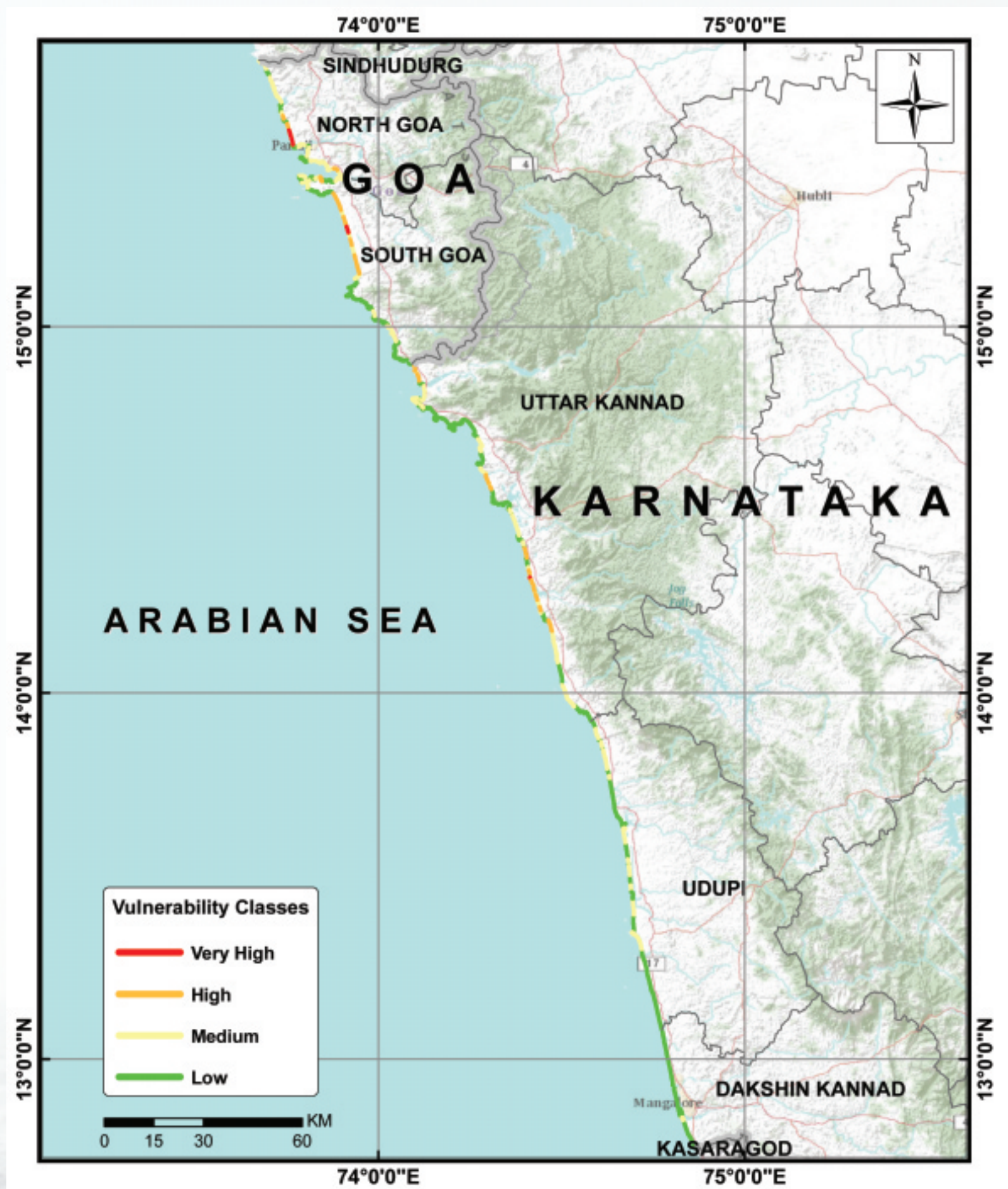


Figure 7. CVI map of Karnataka and Goa

4.4 Kerala

Kerala is located in the southwestern part of India and embraces the coast of Arabian Sea to the west and is bounded by the Western Ghats to the east. This South Indian state stretches from north to south along the coast line of 580 km with an approximate width ranging from 35 to 120 km. Lying within longitudes 74.87 E and 72.37 E and latitudes 8.30 N and 12.80 N. The coastal districts of Kerala are Alappuzha, Ernakulam, Kannur, Kasaragod, Kollam, Kozhikode, Malappuram, Thiruvananthapuram and Thrissur. The total population of these coastal districts is 25.4 million having an average population density of 1,111 people per sq km. Out of all the coastal districts Thiruvananthapuram is the most densely populated district with 1,509 people/ sq km.

The corresponding length of different risk classes due to each of the input parameters for the Kerala state is tabulated in the Table 9. Most of the area in the state of Kerala can be considered as gentle slope, thus nearly 479 km coastline is classified as Very High Vulnerable. CVI analysis due to the shoreline change rate factor indicates that 112 km of coastline is classified as Very High Vulnerable. From the shoreline change analysis, the state of Kerala on an average experiences a maximum erosion of 6 m/y (-) and accretion of 8 m/y (+). The major geomorphic classes of the state are: sandy beaches, coastal plains, wetlands (inundated coasts) and estuaries. The mean significant wave height in the state ranges from 1.3-1.5m and tidal-range ranges from 1-1.7m.

Table 9 Rank versus length of parameters along Kerala Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	215	98	121	77	112
Coastal Slope	21	2	25	96	479
Elevation	6	5	76	372	164
Geomorphology	86	49	--	241	246
Sea level Change Rate	85	69	61	195	213
Mean Significant Wave Height	276	125	113	53	56
Tidal Range	257	60	67	70	168

The CVI analysis reveals that 15 km of coastline was classified as Very High Vulnerable accounting for 2.39 % of the total coastline. Large extent (50.20 %) of the coastline (a length of 313 km) was classified as Low Vulnerable. The Medium Vulnerable and High Vulnerable classes recorded a length of 243 km and 53 km, respectively accounting for about 38.94 and 8.46 percentages respectively (Table 10 and Figure 8). The distribution of the CVI categories along the Kerala coast is shown in the Figure 9. Parts of Kasaragod and Kannur districts were categorized as Very High Vulnerable class (Figure 9).

Table 10 Statistics of CVI along Kerala

CVI	Length (km)	% of Length
Low	313	50.20
Medium	243	38.94
High	53	8.46
Very High	15	2.39
Total	623	100.00

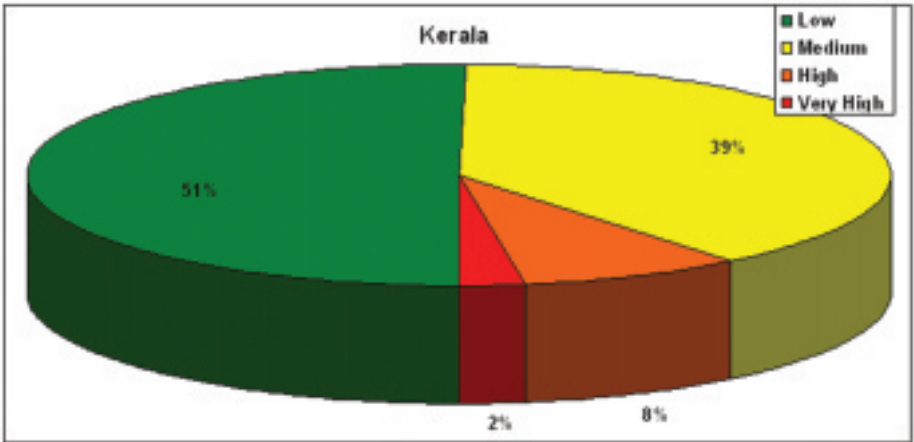


Figure 8 Pie chart is depicting the statistics of CVI classes of Kerala



Figure 9 CVI map of Kerala

4.5 Tamil Nadu

Tamil Nadu is the southernmost state in India with a geographical area of 1, 30,058 sq. km making it the 11th largest state in India. It is located between 8.00 N to 13.50 N latitude and 76.25 E to 80.30 E longitudes. The Union Territory of Pondicherry is a small enclave in the district of South Arcot.

Out of 29 districts in Tamil Nadu the coastal districts including the Union Territory Pondicherry are: Thiruvallur, Kanchipuram, Vizhuppuram, Cuddalore, Nagappattinam, Thiruvarur, Thanjavur, Pudhukkottai, Ramanathapuram, Tuticorin, Thirunelveli, Kanyakumari, Chennai and Pondicherry. The total population of the coastal districts is 33.37 million (except UTs) having a population density of 2,655 person per sq km. The highest population density is in Chennai district with 26,903 persons per sq km. Tamil Nadu coast experiences major threat from tropical cyclones, tsunami, and coastal erosion. The ecological sensitive area, Gulf of Mannar is exposed to other risks due to flooding, siltation and over fishing.

The length of risk categories along the Tamil Nadu coast is tabulated in the Table 11. The slope and elevation factors account for a length of 993 km and 879 km of Very High Vulnerable class, respectively. The geomorphology factor of the area accounts for a length of 544 km in the very high risk category; whereas the other parameters shoreline change rate, tidal range, sea level change rate and MSWH are negating the trend depicted by other factors.

Table 11 Rank versus length of parameters along Tamil Nadu Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	419	185	165	106	150
Coastal Slope	8	8	7	10	993
Elevation	1	2	10	133	879
Geomorphology	4	169	65	243	544
Sea level Change Rate	209	326	202	151	137
Mean Significant Wave Height	284	524	8	86	125
Tidal Range	393	352	–	139	140

The CVI analysis reveals that the Very High Vulnerable category recorded 65 km constituting 6.38 % of total length of the state. Most of coastline (55.72 %) of Tamil Nadu can be classified as Low Vulnerable, with a length of 571 km. The Medium and High Vulnerable classes recorded 309 km and 80 km, respectively accounting for 30.12 % and 7.79 % respectively (see Table 12 and Figure 10). The distribution of the CVI categories along the Tamil Nadu coast is presented in the Figure 11. It reveals that the coastal parts of the Kanchipuram, Chennai and Thiruvallur districts are under Very High Vulnerable category.

Table 12 Statistics of CVI along Tamil Nadu

CVI	Length (km)	% of Length
Low	571	55.72
Medium	309	30.12
High	80	7.79
Very High	65	6.38
Total	1025	100.00

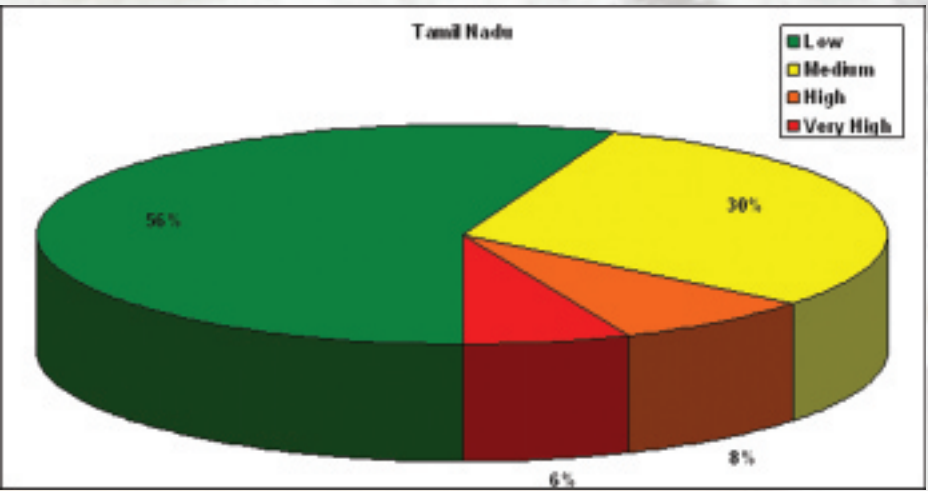


Figure 10 Pie chart is depicting the statistics of CVI classes of Tamil Nadu

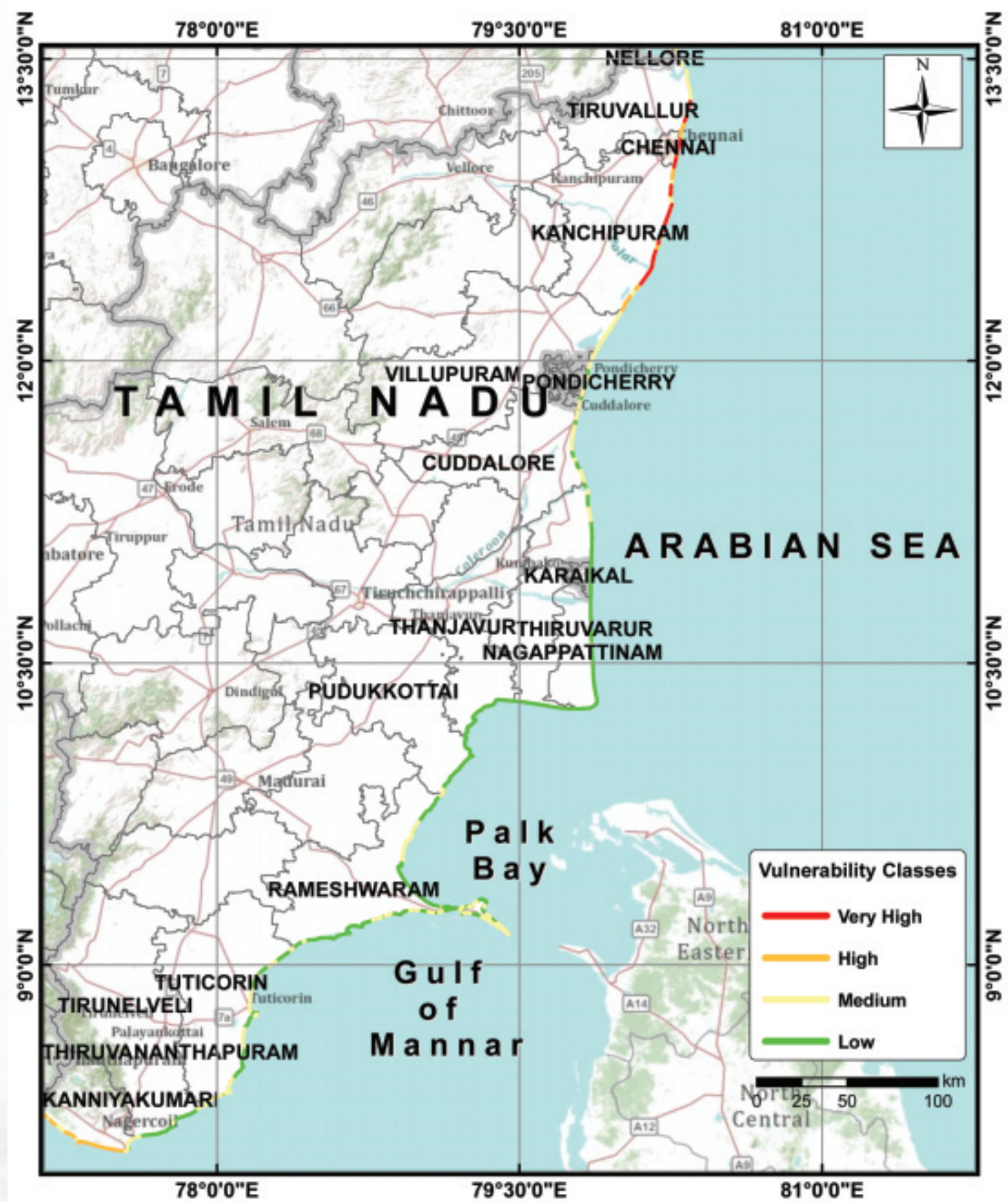


Figure 11 CVI map of Tamil Nadu

4.6 Andhra Pradesh

The state of Andhra Pradesh is situated in the southeastern part of India adjoining the Bay of Bengal to the east. The geographical extent of the state is between 12.23 N to 19.90 N latitudes and 76.77 E to 84.83 E longitudes, with an area of 2,75,100 sq. km. Demographically it is the fourth largest state in the Indian Union with a population nearly 84.6 million (Census of India, 2011) and the population density of 310 people per sq. km. The state is divided into three regions: Coastal Andhra, Rayalaseema, and Telengana. Coastal Andhra region is under tremendous pressure than the other two regions, as it accounts for one third of the land area and two fifth of the State's population.

Coastal districts of Andhra Pradesh are: Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam and Nellore. The state has a long coastline extending from Ichapuram sands in Srikakulam district to Pulicat Lake in Nellore district (IHS, 2009). A total of 2,482 villages exist along the coastline (Somayajulu, 2005) covering an area of 92,906 sq. km with a total population of 34.2 million representing an average population density of 368 people per sq km. There are 500 villages situated in the proximity of 5 km from the coast.

The Table 13 tabulates the length of Andhra Pradesh coastline falling under the five risk classes, with respect to the input parameter/factor. The results indicate that the very high risk in the region is due to: coastal slope, elevation, geomorphology and MSHW; whereas the parameters shoreline change rate and tidal range account for low risk rate.

Table 13 Rank versus length of parameters along Andhra Pradesh Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	734	156	63	23	97
Coastal Slope	7	24	41	69	932
Elevation	12	4	22	134	901
Geomorphology	48	108	--	116	803
Sea level Change Rate	45	56	118	67	211
Mean Significant Wave Height	372	2	2	--	698
Tidal Range	622	350	1	100	0

The CVI analysis for the state of Andhra Pradesh state reveals that the length of 6 km (~0.55 %) is under Very High Vulnerable. The majority of the coastal stretches belong to Low and Medium Vulnerable class recording a length of 465 km and 379 km, respectively (accounting for 43.35 % and 33.27 % of the total coastline respectively). High Vulnerable class was recorded along 224 km of coastline (~21 %) (refer to Table 14 and Figure 12). The distribution of the CVI classes along the coastlines of Andhra Pradesh has been presented in the Figure 13. The coasts of Krishna, West Godavari, East Godavari, Vishakhapatnam, Vizianagaram and Srikakulam districts were classified as Medium to High Vulnerable class. In general, the southern parts of the Andhra Pradesh coast are less vulnerable when compared to the northern parts.

Table 14 Statistics of CVI along Andhra Pradesh

CVI	Length (km)	% of Length
Low	465	43.35
Medium	379	35.27
High	224	20.84
Very High	6	0.55
Total	1073	100.00

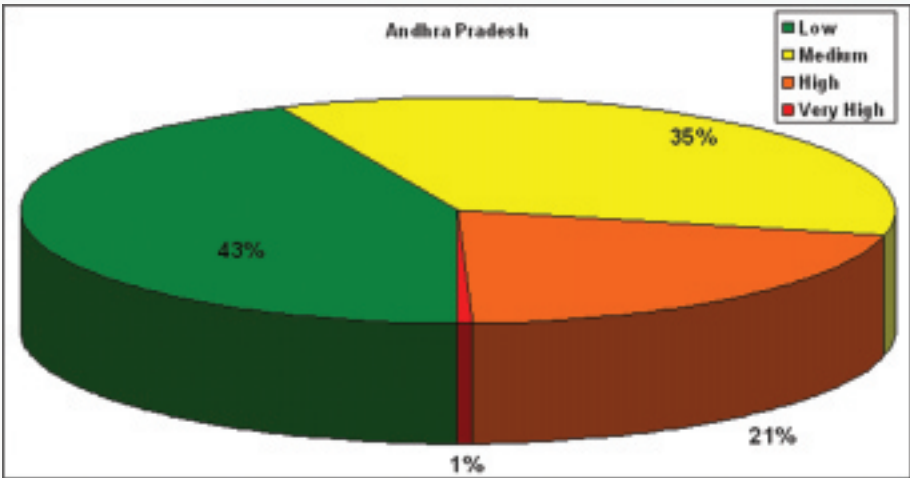


Figure 12 Pie chart is depicting the statistics of CVI classes of Andhra Pradesh



Figure 13 CVI map of Andhra Pradesh

4.7 Odisha

Odisha (formerly, Orissa) is located on the eastern coast of India between 17.82 N to 22.57 N latitudes and 81.45 E to 87.48 E longitudes covering an area of 1,56, 000 sq. km. The total population of Odisha is 41,947,358 (2011 census) with an average population density of 273 persons/sq. km. The state has a total of 30 districts of which six are coastal districts viz. Balasore, Bhadrak, Kendrapada, Jagatsinghpur, Puri and Ganjam. The total population of these six coastal districts is 11,618,570 and covering an area of 21,887 sq. km with a population density of 531 persons/sq. km. Odisha is vulnerable to multiple hazards like: tropical cyclones, storm surges and tsunamis. Extreme sea-levels are major causes for coastal flooding in this region.

The risk classes due to individual input parameters/factors for the Odisha state is tabulated in Table 15. It indicates that coastal slope and elevation are the very high risk factors affecting the coastal length of 453 km and 384 km respectively. The shoreline change rate and the tidal range factors account for very low risk representing 228 km and 201 km respectively.

Table 15 Rank versus length of parameters along Odisha Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	228	134	38	32	65
Coastal Slope	9	6	6	22	453
Coastal Elevation	6	--	18	89	384
Geomorphology	--	254	38	80	124
Sea level Change Rate	45	56	118	67	211
Mean Significant Wave Height	80	58	93	105	161
Tidal Range	201	91	76	64	63

The CVI assessment for the Odisha state indicates that a length of 37 km (~7.51 %) is under Very High Vulnerable category. The major class is the Medium Vulnerable recording a length of 267 km (~53.78 %); whereas the Low and High vulnerable classes recorded a length of 106 km and 86 km (constituting 21.29% and 17.42%) respectively (refer to Table 16 and Figure 14). The spatial distribution of the vulnerability classes along the coasts of the state is shown in the Figure 15. The coastal stretches of Puri, Jagatsingpur, Kendraparha, Bhadrak and Baleshwar recorded High to Very High Vulnerable classes. In general, the CVI analysis shows the northern parts of the coast as Medium to Very High Vulnerable except for a few low category patches; whereas the southern parts of the state were categorized as Medium to Low Vulnerable classes.

Table 16 Statistics of CVI along Odisha

CVI	Length (km)	% of Length
Low	106	21.29
Medium	267	53.78
High	86	17.42
Very High	37	7.51
Total	496	100.00

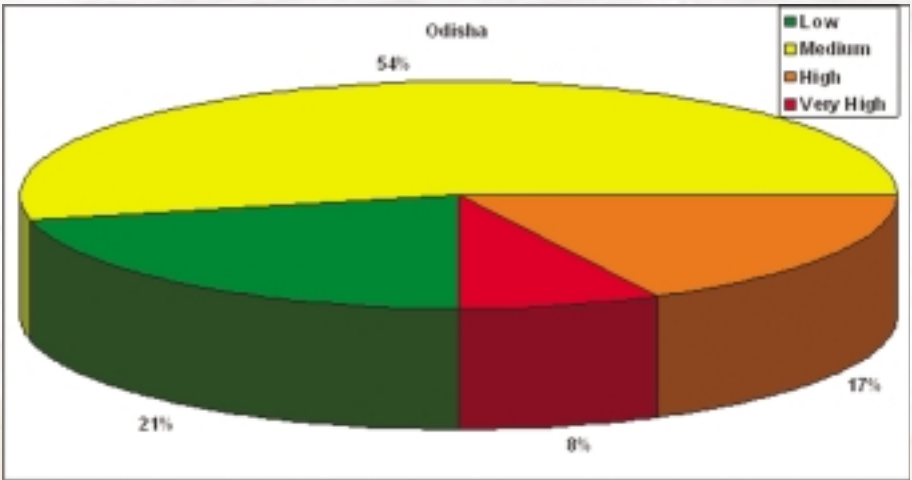


Figure 14 Pie chart is depicting the statistics of CVI classes of Odisha

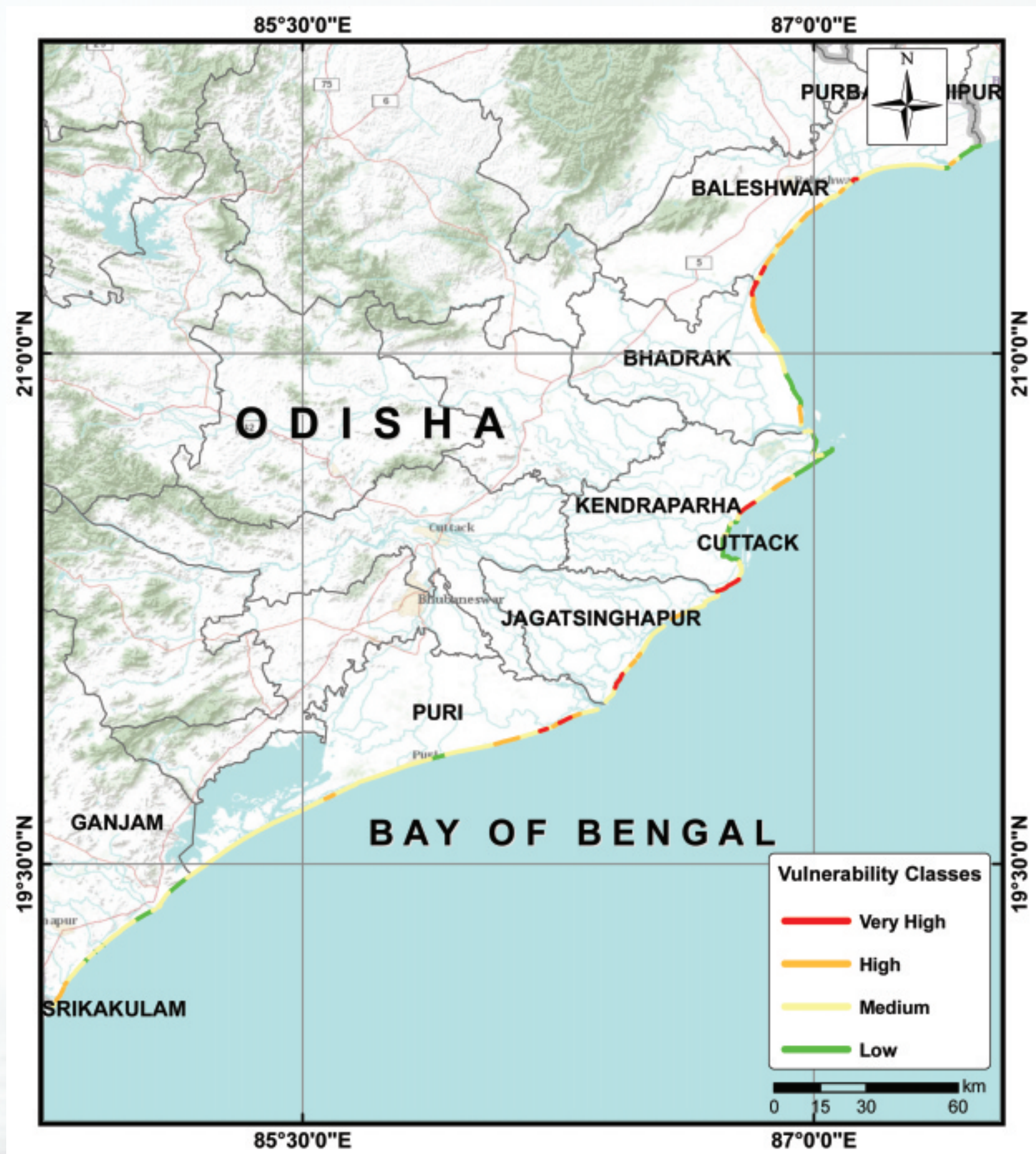


Figure 15 CVI map of Odisha

4.8 West Bengal

The state of West Bengal is situated in northeastern parts of India bounded by the northern Bay of Bengal to the south, covering an area of about 88,752 sq. km consisting of 19 districts. The total population of the state is 91,347,736 (2011 census). The geographical extents of the state is between 21.63 N to 27.17 N latitude and 85.63 E to 89.83 E longitude. Out of the 19 districts in the state, there are three coastal districts: East Midnapur, North 24 Parganas and South 24 Parganas including the group of islands: Sagar, Mahishani, Namkhana and Frasergunje. The West Bengal coast falls under the macro-tidal environment with a tidal range of 5-6m. The total population of these three coastal districts is 23,330,266 (2011 census). The average population density of East Midnapur, North 24 Parganas and South 24 Parganas are: 1,065, 2,462 and 819 people/sq. km, respectively. The average population density in the coastal districts of West Bengal is 1,449 people per sq km.

The length of risk categories due to the individual input parameters is presented in the Table 17. The factors coastal slope and elevation cause Very High risk and account for a length of 985 km and 1197 km, respectively. A length of 594 km was classified under low risk category due to the shoreline change rate, while the rest of the parameters recorded maximum lengths in the Low to High risk categories.

Table 17 Rank versus length of parameters along West Bengal Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	594	666	361	132	174
Coastal Slope	58	126	205	552	985
Elevation	3	10	32	685	1197
Geomorphology	--	1418	451	30	28
Sea level Change Rate	316	555	549	325	181
Mean Significant Wave Height	196	350	430	544	408
Tidal Range	346	459	453	443	227

The CVI analysis reveals that a length of 79 km of West Bengal's coastline (accounting 2.56 %) was categorized as Very High Vulnerable class. Large coastal stretches (1190 km) are under Medium Vulnerable class constituting 61.76 % of the state's coastline. Low and High Vulnerable classes recorded 297 km and 391 km, respectively, accounting for 15.39% and 20.29% of the total coastline, respectively (refer to Table 18 and Figure 16). The spatial distribution of the CVI classes along the West Bengal coast is shown in Figure 17. Parts of coastal areas along the Nayachar Island, North of Sagar, North and South 24 Parganas were classified as High to Very High Vulnerable classes.

Table 18 Statistics of CVI along West Bengal

CVI	Length (km)	% of Length
Low	297	15.39
Medium	1190	61.76
High	391	20.29
Very High	49	2.56
Total	1927	100.00

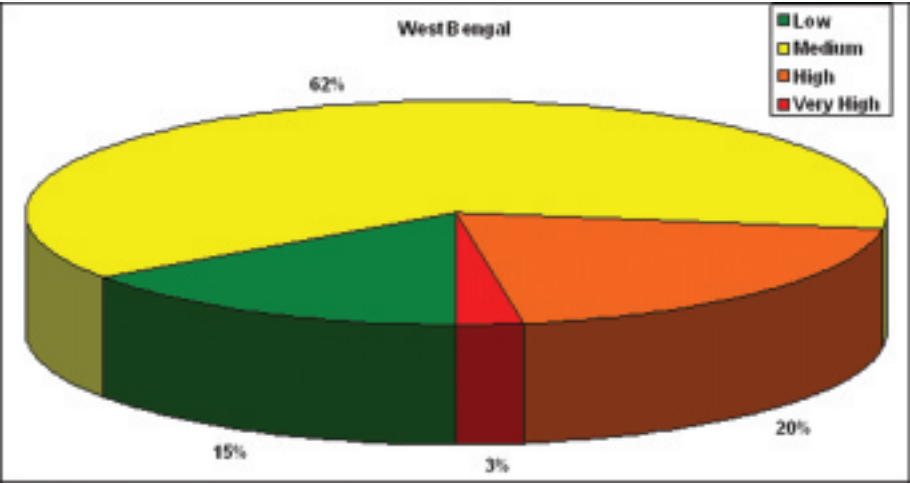


Figure 16 Pie chart is depicting the statistics of CVI classes of West Bengal

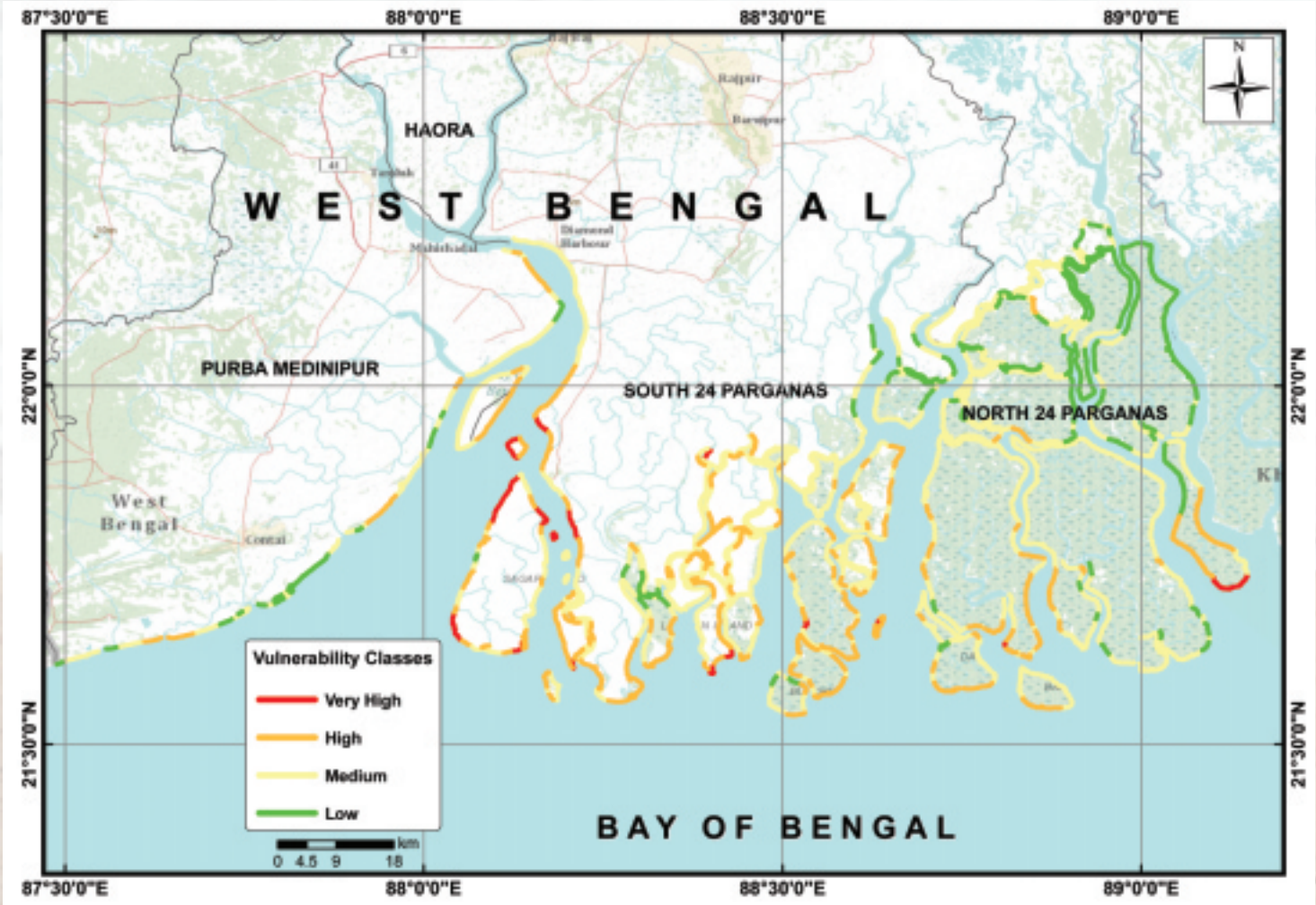


Figure 17 CVI map of West Bengal

4.9 Lakshadweep Islands

Lakshadweep Islands are the smallest Union Territory in India, constituting an archipelago of 12 atolls, three reefs and five submerged banks. It is a uni-district Union Territory with a total area of 32 sq. km and is comprised of ten inhabited islands, 17 uninhabited islands, attached islets, four newly formed islets and 5 submerged reefs. Lakshadweep Islands are distributed between 8.00 N to 12.22 N latitude and 71.00 E to 74.00 E longitude, in the Arabian Sea. The vulnerability study was carried out for the 13 Lakshadweep islands viz., Agatti, Amini, Androth, Bangaram, Bitra, Cherium, Chetlat, Kadmat, Kalpeni, Kavaratti, Minicoy, Suheli (south and north) and Tinnakara. Out of these the inhabited islands are: Chetlat, Bitra, Kadmat, Agatti, Androth, Kavaratti and Kalpeni. The total population of Lakshadweep Island is 64,429 with an average population density of 2,013 people per sq km.

The length of the coastal stretches of various risk categories recorded by individual input parameters is presented in the Table 19. The input parameters: elevation and geomorphology, factor for Very High Risk with a length of 43 km and 39 km, respectively. The input parameters: shoreline change rate and tidal range, factor for a maximum length of 55 km and 75 km, respectively under Very Low Risk category. The rest of the parameters recorded maximum lengths in the Low to High Risk categories.

Table 19 Rank versus length of parameters along Lakshadweep Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	55	61	21	5	10
Coastal Slope	13	18	33	49	39
Elevation	12	23	28	47	43
Geomorphology	--	--	75	20	58
Sea level Change Rate	28	38	19	56	11
Mean Significant Wave Height	31	--	44	56	20
Tidal Range	75	49	--	--	28

The CVI analysis of the Lakshadweep islands reveals that a total length of 1 km (~0.81 %) of coastline is under Very High Vulnerable class. The majority of the coastlines of these islands are under Medium Vulnerable class with a length of 119 km (~78.52 %). Whereas the Low, and High Vulnerable categories were recorded a length of 23 km and 8 km (~15.43% and 5.24%), respectively (see Table 20 and Figure 18). The map representing the spatial distribution of CVI classes for the Lakshadweep islands is shown in Figure 19. The CVI map reveals that the islands situated in the eastern parts: Androth, **Cherium** and Kalpeni are categorized as High to Very High Vulnerable class. The islands Bitra, Kadmat and Agatti are categorized as Medium Vulnerable class. The rest of the islands in the archipelago belong to Medium to Low Vulnerability class.

Table 20 Statistics of CVI along Lakshadweep Islands

CVI	Length (km)	% of Length
Low	23	15.43
Medium	119	78.52
High	8	5.24
Very High	1	0.81
Total	152	100.00

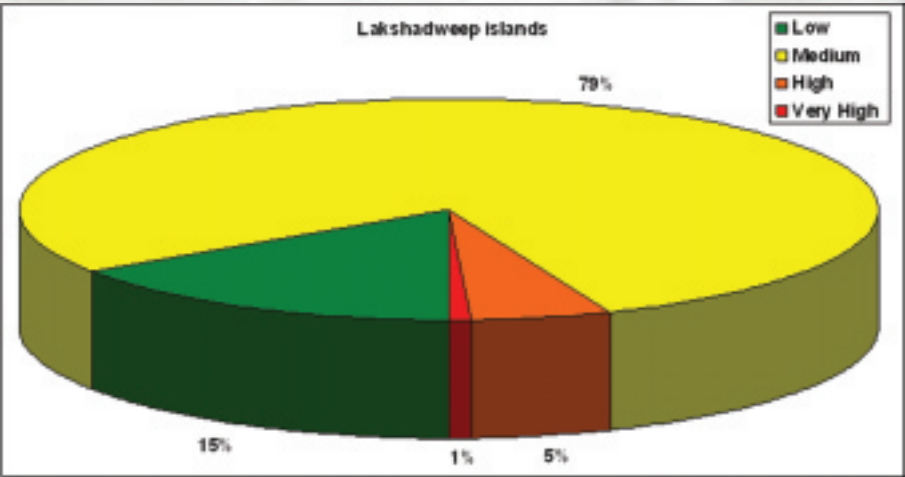


Figure 18 Pie chart is depicting the statistics of CVI classes of Lakshadweep Islands

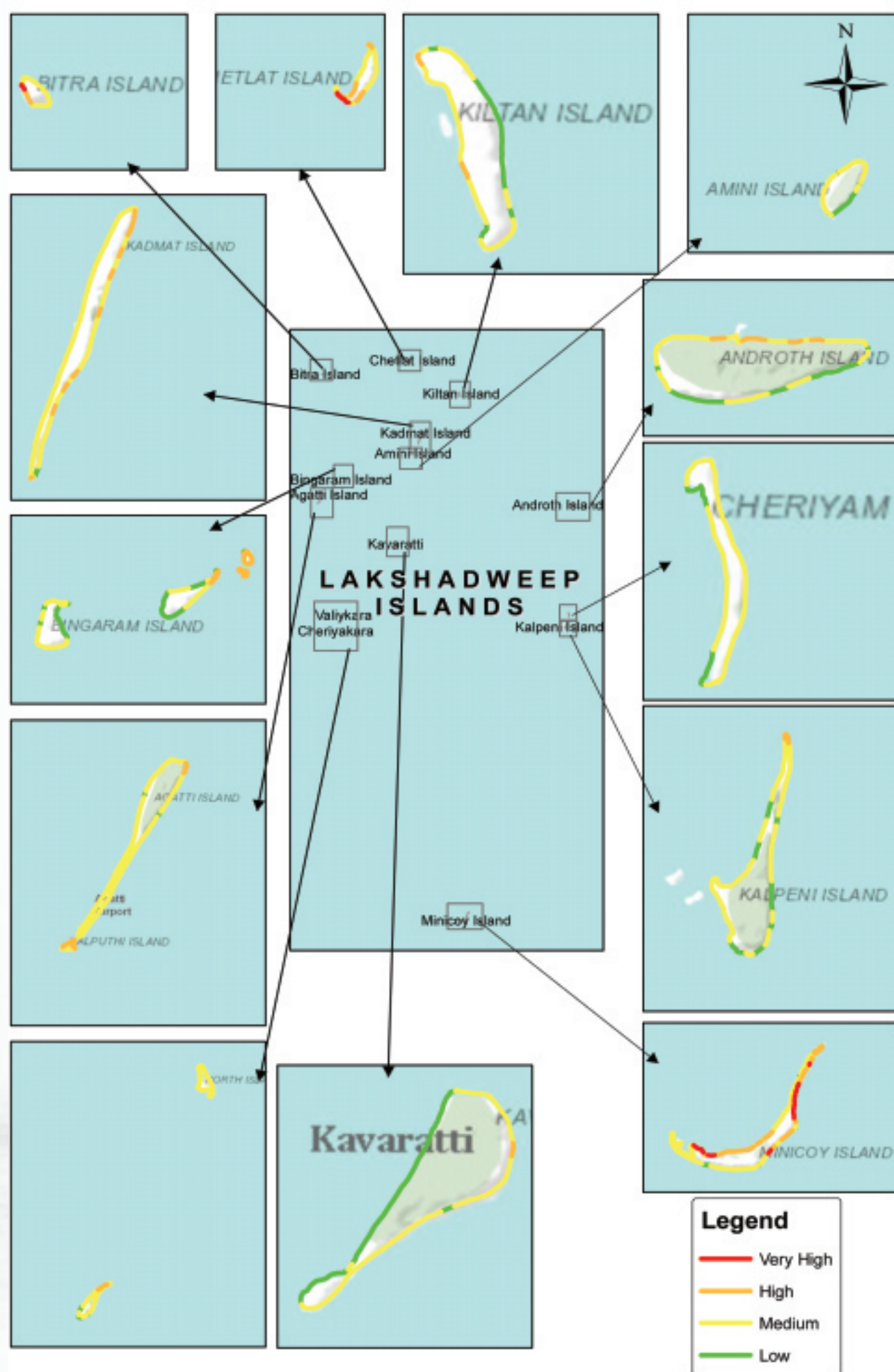


Figure 19 CVI map of Lakshadweep Islands

4.10 Andaman Islands

The group of Andaman Islands is situated in the Bay of Bengal between the peninsular India and Myanmar aligned in the North-South direction. These Islands are located between latitudes 10.35 N and 13.70 N and longitudes 92.20 E and 93.95 E, covering an area of 6,231 sq. km. The Andaman Islands consist of 325 islands of which only 33 are inhabited, 94 islands are sanctuaries including six as national parks, two of which are marine national parks and two islands as tribal reserves in the Andaman. The geomorphology of Andaman has coral reefs, sandy beaches, lagoons, mangroves, creeks, bays, cliffs, saline areas and forestland. The population of Andaman Island is 3.43 Lakhs with an average density of 55 people per sq. km.

The length of the coastal stretches of various risk categories recorded by individual input parameters is presented in the Table 21. The input parameters: coastal slope and elevation factor for Very High Risk and account for a length of 221 km and 1000 km, respectively. The shoreline change rate accounted for a maximum length of 1022 km under the Very Low Risk category, while the rest of the input parameters account for maximum length under Low to High Risk categories.

Table 21 Rank versus length of parameters along Andaman Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	1022	618	429	220	161
Coastal Slope	6	17	60	151	2215
Elevation	606	218	277	349	1000
Geomorphology	37	1674	39	15	685
Sea level Change Rate	176	133	716	1045	380
Mean Significant Wave Height	34	885	1113	–	417
Tidal Range	365	342	685	720	337

The CVI analysis for the Andaman Islands indicates that the Very High Vulnerable class recorded a length of 24 km (0.96 %). Majority of the coastal length was categorized as Low and Medium Vulnerable class recording a length of 1139 km (~46.49 %) and 1031 km (42.08 %), respectively. High Vulnerable class recorded a length of 256 km (~10.47 %) (Refer to Table 22 and Figure 20). The CVI map showing the spatial distribution of the CVI classes for the Andaman Islands is shown in Figure 21. The Very High Vulnerable classes recorded along the eastern coast of the middle Andaman and northwestern parts of the North Andaman. Most of the southeastern parts like Little Andaman and Sentinel islands recorded Low Vulnerable class with few stretches of Medium Vulnerable class.

Table 22 Statistics of CVI along Andaman Islands

CVI	Length (km)	% of Length
Low	1139	46.49
Medium	1031	42.08
High	256	10.47
Very High	24	0.96
Total	2449	100.00

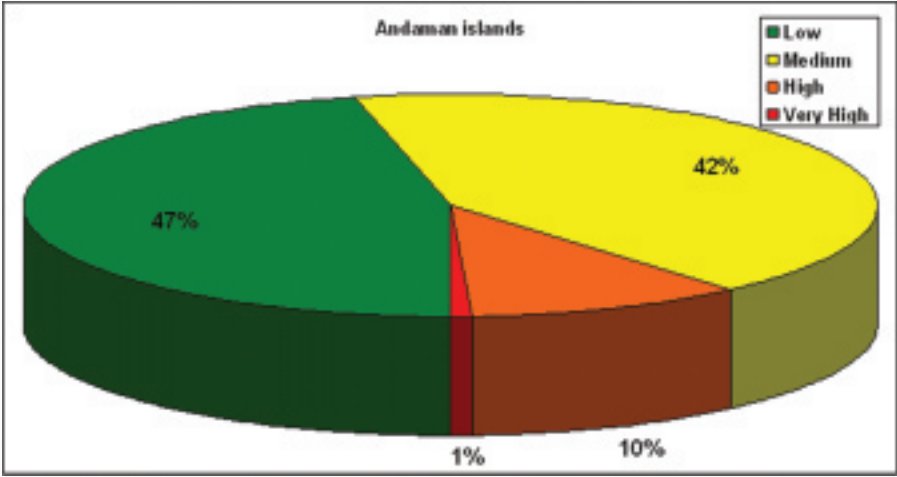


Figure 20 Pie chart is depicting the statistics of CVI classes of Andaman Islands

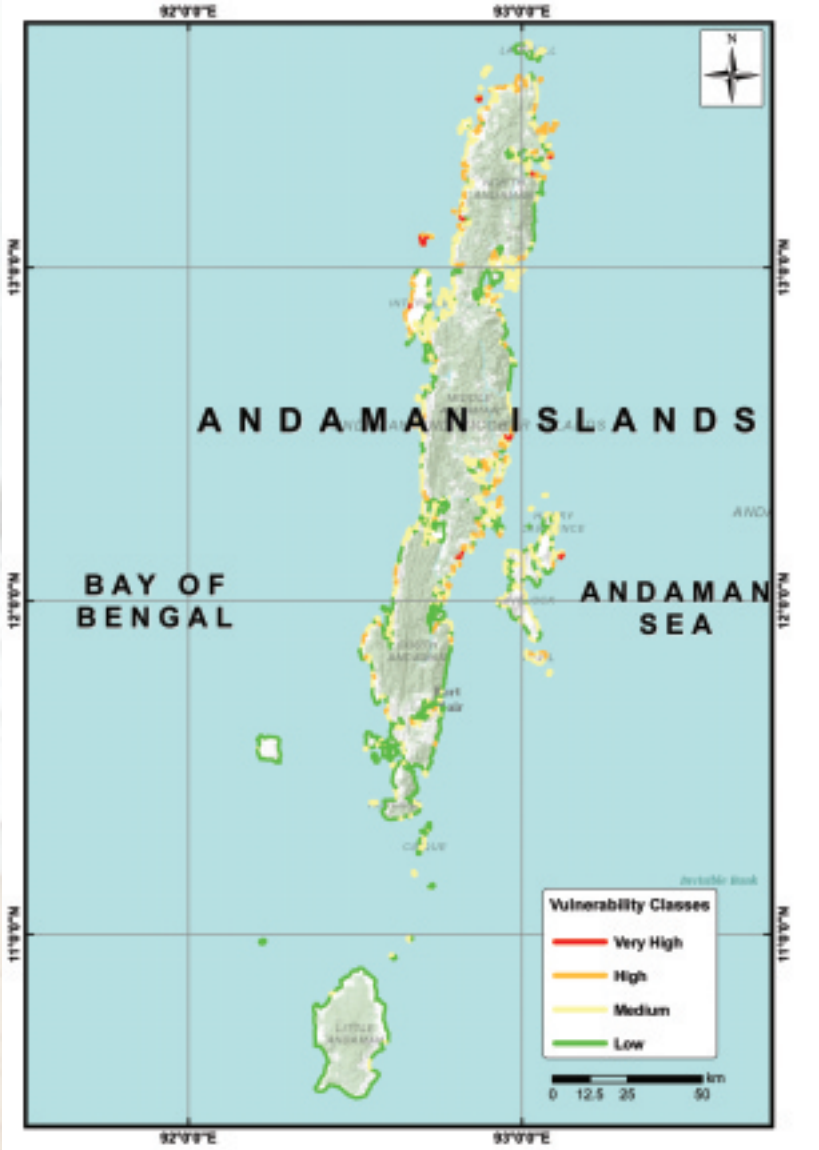


Figure 21 CVI map of Andaman Group of Islands

4.11 Nicobar Islands

The Nicobar Islands are situated to the south of Andaman Islands, and are located about 189 km northwest of the Indonesian island of Sumatra. The total land area of the island is 1841 sq. km. The Nicobar Island is located between latitudes 6.75 N (Indira point) to 9.25 N (North tip of Car Nicobar Island) and longitudes from 92.13 E to 93.95 E. The archipelago includes 22 islands of various sizes, the largest being Great Nicobar, which houses the Indira Point, the southernmost point of Indian Union, and the Mount Thullier, the highest point in the archipelago at 642m above sea-level. The population of the whole island is about 36,819 with density 20 people/sq. km.

The length of the coastal stretches of various risk categories due to the individual input parameters is tabulated in Table 23. The coastal slope factors for a length of 624 km are under Very High Risk category; while the shoreline change rate and MSWH account for Very Low Risk category of length 386 km and 613 km, respectively. The rest of the parameters accounted for a maximum lengths in the Low to High Risk categories.

Table 23 Rank versus length of parameters along Nicobar Coast

Parameter	Length of Risk Classes along the Coastline (km)				
	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Shoreline Change Rate	386	130	121	43	123
Coastal Slope	2	6	37	134	624
Elevation	210	131	213	175	75
Geomorphology	42	545	73	2	141
Sea level Change Rate	186	309	191	50	66
Mean Significant Wave Height	613	--	--	66	124
Tidal Range	121	363	214	49	56

The CVI analysis for the Nicobar Islands indicates that Very High Vulnerable class accounts for 8 km (~0.97 %). Most of the coastline of Nicobar Islands (83.86 %) was classified as Low Vulnerable, accounting for a length of 673 km. Whereas the medium and high vulnerability classes accounted for a length of 84 km (10.49 %) and 38 km (4.68 %), respectively (see Table 24 and Figure 22).

The CVI map for Nicobar Islands is shown in Figure 23. Most of the Carnicobar coastline was categorized as Very High Vulnerable class except for a few stretches of High Vulnerable class. The Teresa Island was categorized as High to Medium Vulnerable class and the rest of the islands were classified as Medium to Low Vulnerable class.

Table 24 Statistics of CVI along Nicobar Islands

CVI	Length (km)	% of Length
Low	673	83.86
Medium	84	10.49
High	38	4.68
Very High	8	0.97
Total	803	100.00

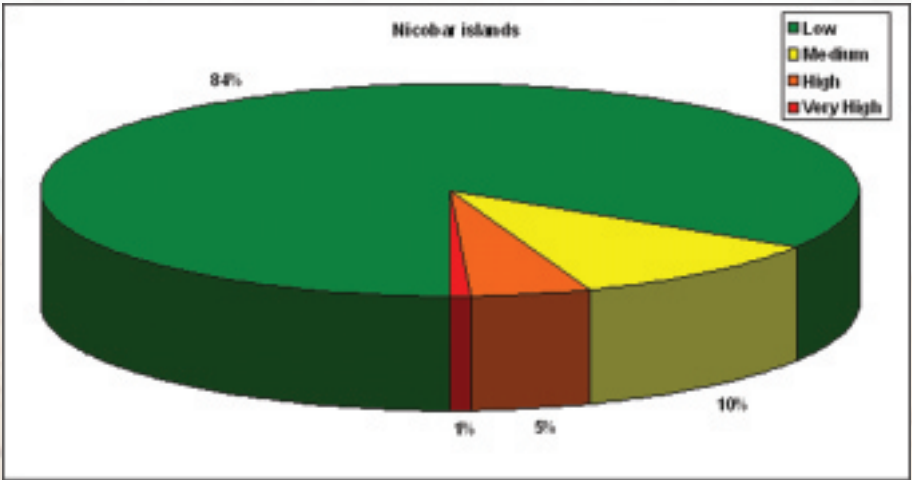


Figure 22 Pie chart is depicting the statistics of CVI classes of Nicobar Islands



Figure 23 CVI map of Nicobar Islands