SENSITIVITY AND VULNERABILITY ASSESSMENT OF SOCIO - ECOSYSTEMS TO OIL SPILL AND SEA LEVEL RISING IMPACT AT HAI PHONG COASTAL ZONE, VIET NAM

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ABSTRACT

Nowadays, people are interested in the Environment issues. However, it implies much significance and is researched under many aspects. The research has addressed and discussed a new topic which is the assessment of sensitivity to oil spill effect to coastal zone, according to the synthesis perspectives of social-ecological vulnerability approaches. Base on considering the damage of Social-ecosystem to oil spill and sea level rise effects, bearing capability of the socio-ecosystems, the vulnerability and sensitivity index for each unit can be assessed. In this paper, vulnerability and sensitivity index of social-ecosystems along coastal zone has been created into a thematic map ranged from 1 to 10. Integrated procedure for creating of those indexes by using remote sensing and GIS technologies are also presented. This study focuses to calculate vulnerability index of oil spill and also to sea level change effects to socio-ecosystems, then establishing environmental sensitivity index map for Haiphong coastal zone, where having the most important harbour in the north part of Viet Nam. By using these indexes, environmental protection plan can be created for sustainable development in general and for early protection for oil spill effects in particular.

KEYWORDS: sensitivity, vulnerability index, oil spill, sea level rising, socio-ecosystems

BACKGROUND TO THE STUDY AREA

The study area in this research is Hai Phong coastal zone, with the geographical coordinates from $20^0$30’39’’ N to $21^0$01’15’’ N and from $106^0$23’39’’ E to $107^0$08’39’’ E, with the area of over 152.318 km^2 and situated about 102 km South East of Hanoi. Hai Phong is one of the most important doors in the North of Vietnam with an important harbour, has greatly attracted foreign investments in many industrial zones. On the other hand, Hai Phong coastal zone has Cat Ba Island with very high diversity and just become a world diversity reservation area. Each year, Hai Phong faces with about from 6 to 10 typhoons. Hai Phong has dynamic activities such as transport, tourism,

aquaculture… so that, the area has many conflicts between development and environmental protection, especially oil spill effecting.

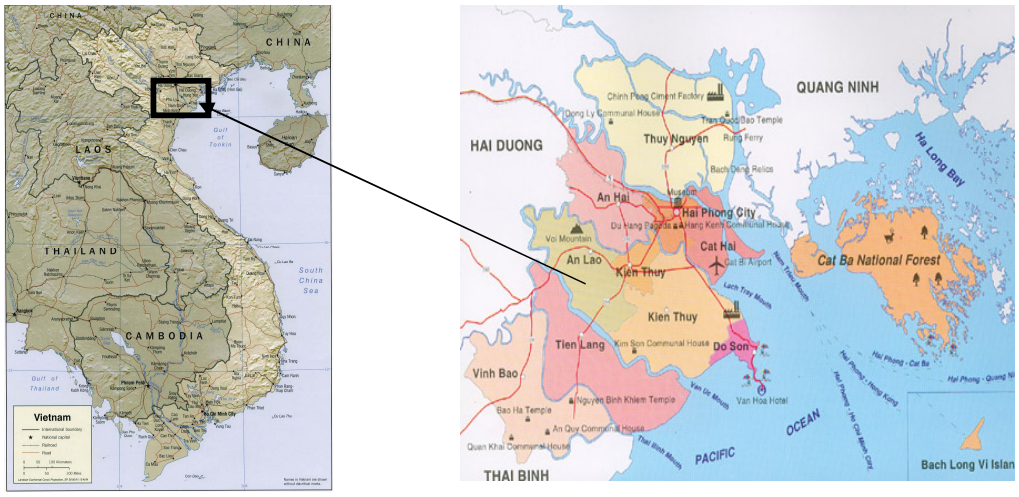

Fig.1. location of the study area

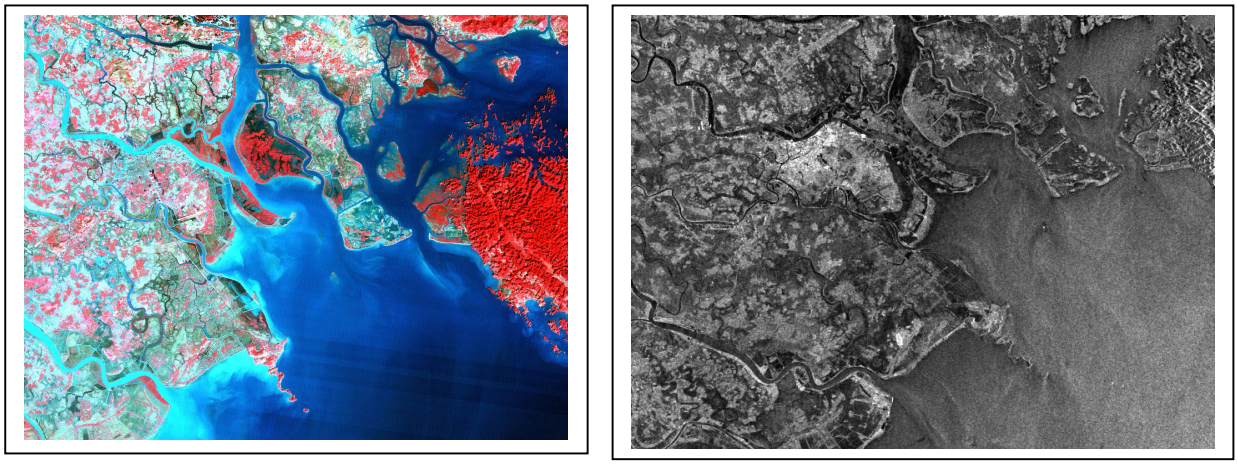

Fig2. Landsat image (Dec/ 2000) (left) and Radarsat image (Dec/ 2000) (right) of the study area

The morphology, geology and lithology of Hai Phong are complex, resulting in great variations in rock types and structures, all of which control the coastal form. The animal life in the Cat Ba islands is important because of the plentiful of diversity with many species: fish, coral reff, seals, otters and sealsand plantations. Any threat to them can easily displace their delicate position in the ecosystem.

THEORETICAL BASE

+ Sensitivity analysis is the study of how the variation (uncertainty) in the output of a mathematical model can be apportioned, qualitatively or quantitatively, to different sources of variation in the input of the model

Effects in the study area content of nature such as: typhoon, coastal errosion, salinity, related to climate change and sealevel and socio-activities effect as oilspill .

A technique used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions. Sensitivity analysis is a way to predict the outcome of a decision if a situation turns out to be different compared to the key prediction(s).

The project has addressed new research problem that is the assessment of environmental sensitivity according to the perspectives of ecological-based approaches and synthesis. In nature, a ecological unit can be effected with single impact but in general, it is effected by several impacts silmutaneously. For sensitivity analysis, indexes can be calculated separately for each ecological component but in natural condition index should be a synthetize value. For mapping, indexes are calculated for separately boundary of each ecological unit and detail of its depending on scale of the study .

+ Vulnerability **assessment** is the process of identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in a system. Vulnerability from the perspective of disaster management means assessing the threats from potential hazards to the population and to infrastructure. It may be conducted in the political, social, economic or environmental fields. The basic methodology of constructing a vulnerability index is described by Briguglio and is quite simple and not without antecedents. Different relative importance is assigned to the different factors (weighting).

Once the credible threats are identified, a vulnerability assessment must be performed. The vulnerability assessment considers the potential impact of loss from a successful attack as well as the vulnerability of the facility/location to an attack. Impact of loss is the degree to which the mission of the agency is impaired by a successful attack from the given threat. A key component of the vulnerability assessment is properly defining the ratings for impact of loss and vulnerability. These definitions may vary greatly from facility to facility.

A combination of the impact of loss rating and the vulnerability rating can be used to evaluate the potential risk to the facility from a given threat.

Vulnerability depending on levels of risk can be happened with different level of impact. Normally, the maximum index is calculated for the maximum impact with qualitative assessment. Ranking for indexing can be changed from 1 to 5 or 10, depending on the scale of study and statistic data of risk. In general, vulnerability index of each factor can be assessed corresponding with the sensitivity indexes, damage or risk with the maximum impact.

With this concept, the environmental database of Haiphong's was established at scale 1:50,000, including environment component maps (geology, geomorphology, climate, hydrology, oceanography, vegetation...) and 42 ecosystems existing in the territorial space of Haiphong's coastal zone. Data used for mapping are different type of grounf truth datand satellite images such as LANDSAT 7, SPOT 4, 5, IKONOS, quickbird and Radarsat image (fig 4)

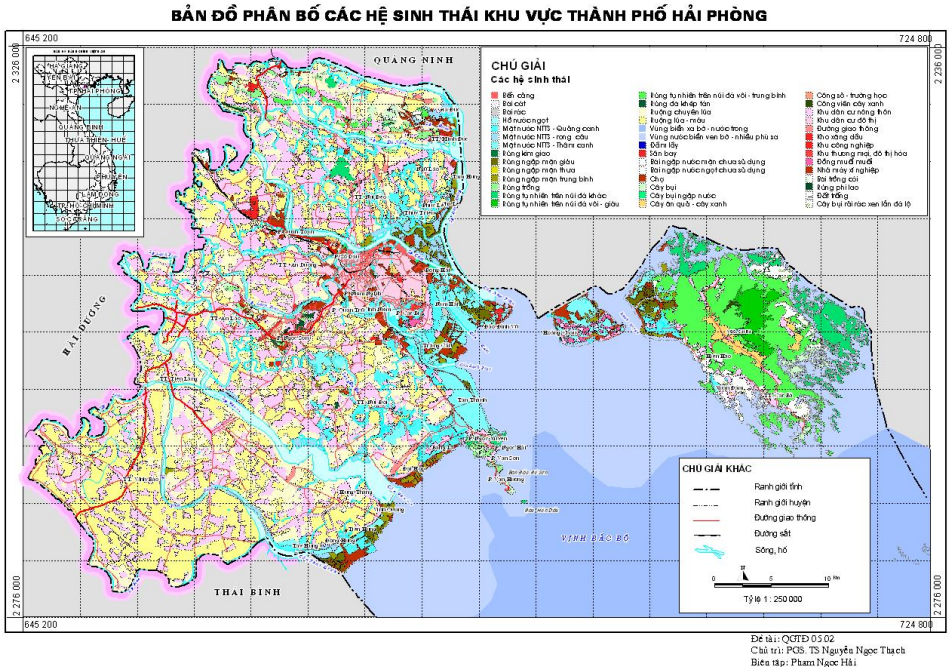

Fig 3. Socio- ecological systems map of Hai Phong

Sensitivity and vulnerability index for ecology units can be assessed as follow:

$$E = 1/m \sum_{1}^{n} (\alpha A + \delta B + \gamma C...)$$

Where: E: Sensitivity index of each ecological map units - output values with maximum value of impacts.

m: Ranking of index value (from 1-m)

1..... n: Information layers (from 1-n)

α, δ, γ... : Weighted values for separated layer

A, B, C...: weighted layers of separated factor.

GIS software was used as Envi 4.2, ArcGIS 9.2.... to estimate sensitivity index for separated layer then to combine, reclassify into synthetic values.

SENSITIVITY ASSESSMENT AND MAPPING TO OIL SPILL IMPACT

For prevention of oil spill effect, a sensitivity mapping to oil spill has been established using Remote Sensing and Geographical Information system.

The basic aim of the study was to create within the GIS an environmental sensitivity model for oil spills occurring within the study area. To set up such a usable model the methodology adopted had two parts; the creation of the basic thematic coverages of interest, and the spatial and aspatial analyses that were performed on them.

The environmental sensitivity model was built in the form of thematic coverages, each pertaining to a specific feature of interest found in the study area. These can be subdivided into physical and ecological characteristics. As this was a pilot study, only the more important features were digitised into the GIS. The included physical features were the general coastline classification, the sensitivity of shores along the coast, and their exposure to wave fetch. For the ecological features, only the presence of birds, otters and seals, and other related information were digitised. One other coverage, which of the access to the coast, was also deemed important for this study. In themselves, these coverages are useful in number of ways. Users can query any of them to extract information stored within the attribute files. Alternatively, all or appropriate sections of the study area can be plotted as maps, which can then be used by oil spill response teams during actual operations.

Khu vực quy hoạch nuôi cá lồng bè của huyện Cát Hải

Fig 4. Some typical Cosio-ecosystem in the study area

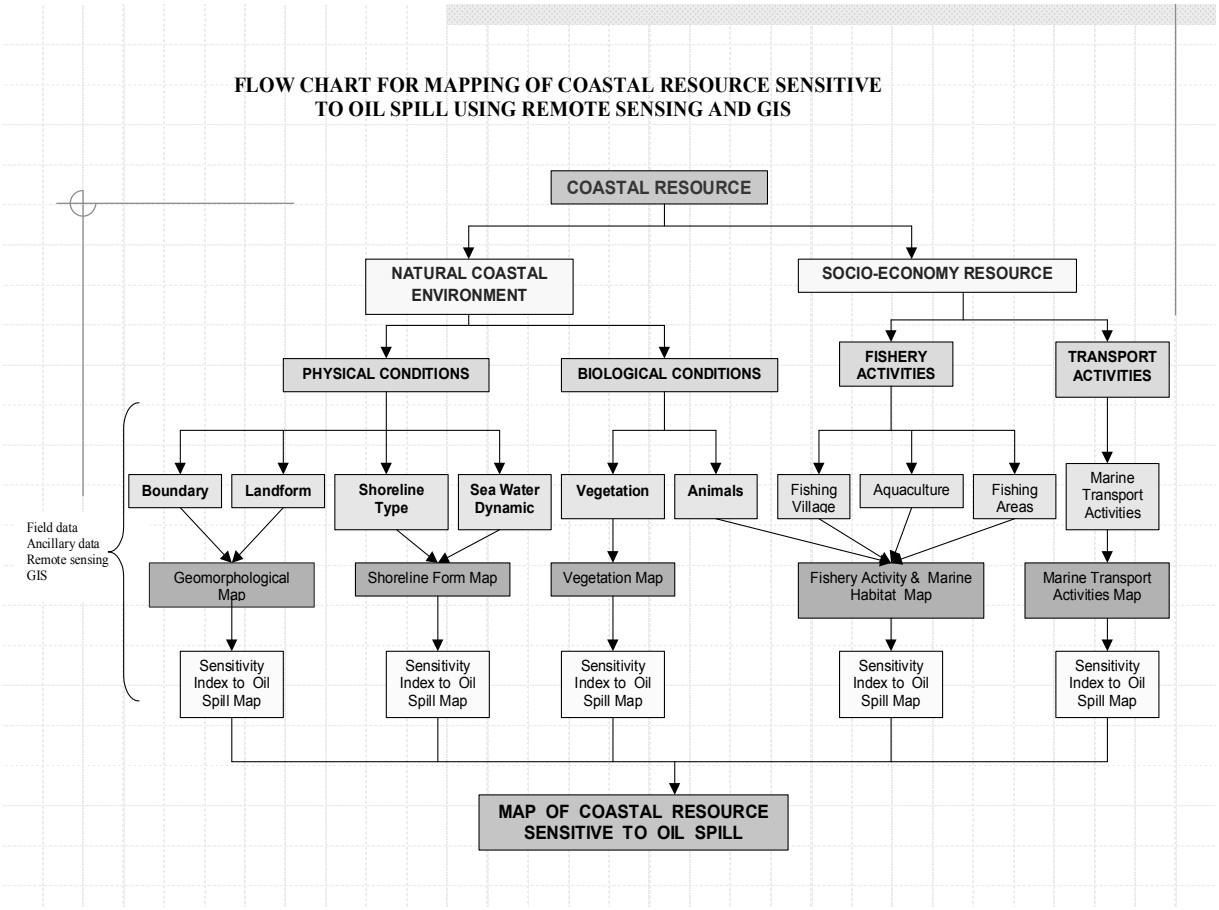

Figure 5. Flowchart of the study

The environmental database of Haiphong's ecological sensitivity (at scale 1:50,000) including environment component maps (geology, geomorphology, climate, hydrology, oceanography, vegetation...) and 42 ecosystems existing in the territorial space of Haiphong's coastal zone.

Table 1. Description for oil spill sensitivity indexes

	NATURAL CONDITION				DIVERSITY				SOCIO-ECONOMY		
CSI	COASTAL GEOMORPHOLOGY		SEA WATER DYNAMIC		VEGETATIONS		MARINE HABITAT				
	LANDFORM	SHORE TYPE	WAVE	TIDAL	MANGROVE (density)	NIPAH	LITHORAL	SUB-LITHORAL	FISHERMAN	FISHING (frequency)	TRANSPORT
1	Land with several tidal effecting sea walls, road, platform, concrete	closed coast	high to medium	medium - high 2.8m -3.5m	sparse	sparse	rich-medium crab, izopod, bernacles, gastropods, bivales, limple	rich	<100	poor-moderate	high
2	fine grain sandy beach, sea shell beach	semi-open	moderate-high	medium 2.8m - 3.2m	sparse	sparse dense	rich-medium hemicrab, shell	rich-medium	100-150	poor-moderate	moderate
3	border beach (not concrete)	open-closed	moderate-low	medium-high 2.5m-3.5m	sparse	sparse	medium-rich hemicrab, snail	medium-low	150-200	poor-moderate	moderate
4	exposed fine sand beach, steep-gentle slope, narrow	open-semi closed	moderate	high-medium 2.8m-3.5m	medium	medium	rich-medium snail, shell	medium-rich	200-250	moderate-poor	moderate
5	exposed mud-sandy beach, steep slope. shallow sea water	open	moderate-high	3.2m-3.8m	medium	medium	rich-medium crab, shell, worms, bivales	medium-low	250-300	moderate	moderate
6	exposed mud tidal flat, gentle slope medium width	open	high	3.8m-4.3m	dense average	medium rich	rich-medium crab, shell, wor	rich-med diun	300-400	large average	medium-high
7	exposed mud tidal flat, large width	open or semi open	high	3.8m-4.5m	dense-medium	rich	rich	rich	400-500	large-high	high
8	exposed mud tidal flat, open estuary	closed or semi open	medium	3.8m-4.5m	high density	rich	rich	rich	500-600	high	high
9	exposed or sheltered tidal flat, closed or semi close estuary	semi open or close	medium	3.8m-4.6m	dense	very rich	rich	rich	500-1000	high	high
10	exposed tidal flat, closed estuary	semi -open, open	medium	3.8m-4.6m	dense	very rich	very rich	very rich	>1000	high	very high

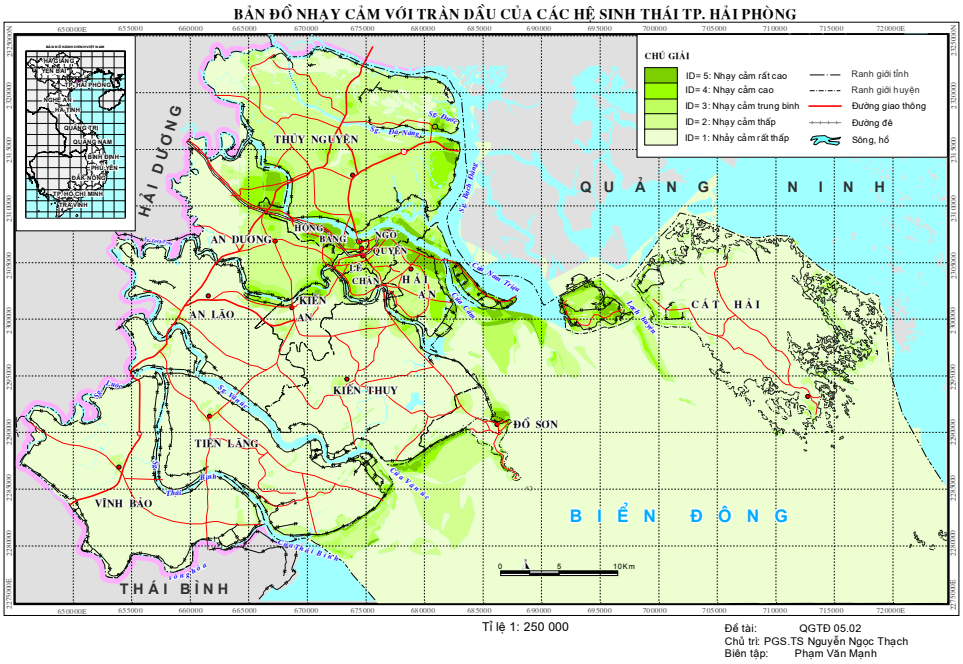

Figure 6. Map of oil spill sensitivity and vulnerability index

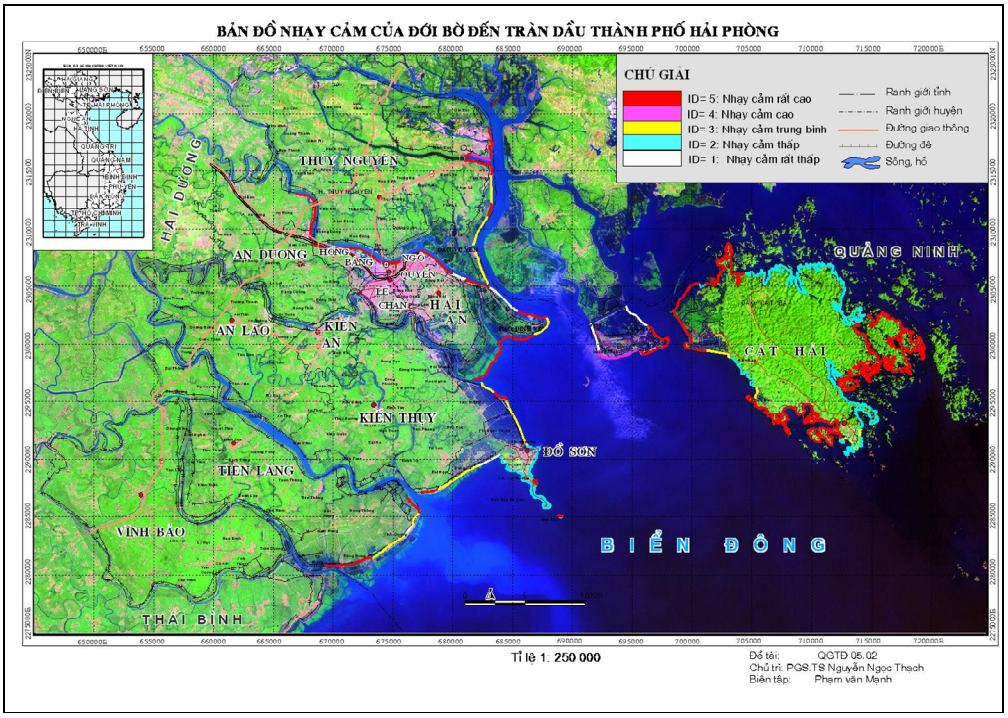

Figure74. Map of coastal oil spill sensitivity and vulnerability index for Hai Phong coastal zone

The sensitivity and vulnerability indexes can be used for environmental planning with the purpose of warning hazards impacts. In other, it can be used for providing scientific background to assist decision maker in selecting investment project. Additionally, the products are the basis to propose administrative, technological and communicated action in environmental planning for sustainable development of the region.

Table 2: Planning for oil spill protection depending on sensitivity indexes

Area	**Sensitivity and vulnerability Index**		**Techniques & Strategy for oil spill protection**
	Level	***index***	
Inland with drainage effected by tidal	Very low	1	Sorption, vegetation cropping
Open sea water	Low	2	Navigation Law control, forecasting by GIS
Sea water with high diversity of sublittoral habitat	Medium	3	Navigation Law control, booms, skimming
Large mud flat with very high diversity, high productive	Medium to high	4	Forecasting by GIS, booms, skimming, manual removal
River with tidal effect, medium to high diversity	Medium to high	5	Booms, manual removal
Flat island with high diversity, high drainage density, tidal effect	Medium to high	6	Manual removal, sorption, booms
Long and narrow mud flat, sea shell beach, medium diversity	Medium to high	7	Booms, manual removal
Large-shallow mud flat, medium to high diversity	High	8	Booms, skimming, natural cleaning
Very high frequency of navigation activity, port activity	Very high	9	Motorized substrate removal, vacuum pump, cleaning machine, sorption, booms, skimming, low pressure pump
Very high frequency of navigation activity, port activity	Very high	10	Motorized substrate removal, vacuum pump, cleaning machine, sorption, booms, skimming, low pressure pump

SENSITIVITY AND VULNERABILITY ASSESSMENT TO SEA LEVEL CHANGE IMPACT

For sea level change impact, number of study has been conducted in the study area. Calculations have determined that the speed of sea level rising in the region about 0.01-0.03 mm per year. In the official scenario on climate change, sea level is suggested rising about 30 cm on 2050. (fig 5). With this prediction, a large area of the region can be effected by sea water rising. Typical natural hazards can be flooding, salinity and coastal line erosion.

Fig.8. Scenario for climate change and sea level rising in Viet Nam

For study, following factors can be assessed as: location and objects will be effected, deep of water, lost can be happened and related hazards can be increated. In the study area, these problems have been calculated for effecting to the Socioecological systems

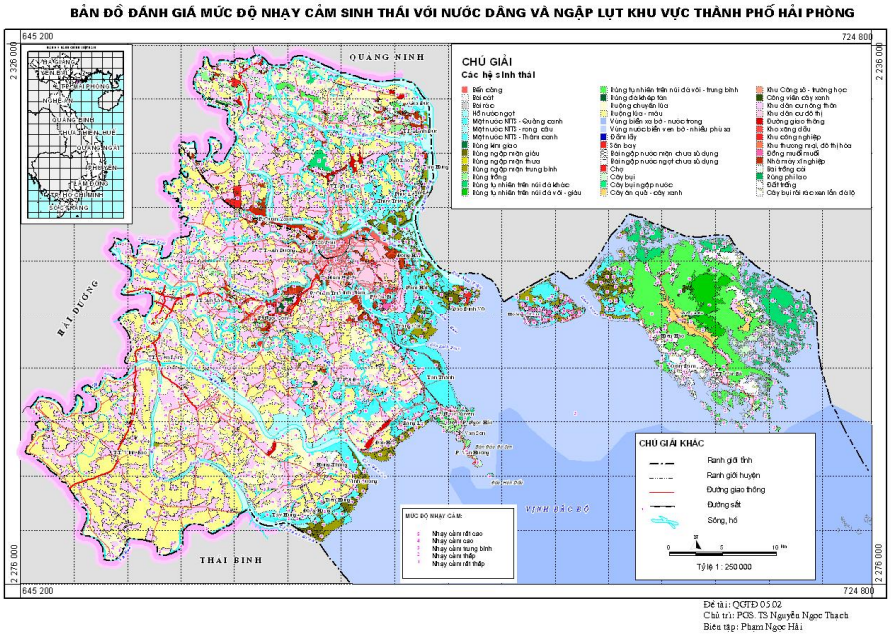

Fig 9. Sensitivity and vulnerability index Map to sea level rising of the study area

CONCLUSSIONS

Recently, a number of GIS and remote sensing systems are being used in not only environmental sensitivity mapping of coastlines for oil spills, but also in the other important aspects of environmental impacts, especially to climate change and sea level rising .

1. Establishing an environmental database of Haiphong's ecological sensitivity (at scale 1:50,000) including environment component maps (geology, geomorphology, climate, hydrology, oceanography, vegetation ...) and 51 ecosystems existing in the territorial space of Haiphong's coastal zone. The data base can be used for different purposes of research and territorial management of Hai Phong city.

2. The more data are collected; new thematic coverages can be produced, stored, updated and analyzed to improve the sensitivity and vulnerability maps or contingency plans.

3. Theoretically, the only constraint on such a system is the amount of data collected by the users. Hence, it can be seen that the use of a GIS in this field is not only viable, but also necessary as the complexities of modern day oil spill response prove beyond the scope which the traditional approach can cope with.

4. The sensitivity and vulnerability index map to sea level rising of the study area is also a new approach to create a product which is the basis to propose administrative, technological and communicated action in environmental planning for sustainable development of the region.

5. Beside of the study on oil spill and sea level rising impacts, data base can be used for establishing ecological sensitivity, vulnerability index and maps of each landscape unit with further impacts as salinization, waste pollution, geological hazards, etc. The products can be applied for environmental planning, for early warning of pollution and hazards and providing scientific background to assist decision maker in selected investment project.

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