IMPACT OF SEA LEVEL RISE ON COASTAL RESOURCE IN VIETNAM

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Abstract

The present sea level rise is related to the sea level rise in Quaternary period. There were 5 cycles in the forming of Quaternary formation corresponding with 5 cycles of regression and alternative 5 cycles of transgression (Tran Nghi, 1991). That is why, the present sea level belongs to the 5th transgression cycle, which began about 500 - 1000 years ago at the end of regression in Late Holocene.

It is clearly seen the effect of the sea level rise through following process and phenomena:

1. The estuarization of Bach Dang river delta has caused strong erosion of southern coast of Cat Hai Island and areas surrounding the river mouth. The area of present delta is only one fourth of Late Holocene deltaic plain. The Nha Mac marshy used to be a high land in the past now is deeply submerged in seawater, meanwhile the tidal channel to Hai Phong port became shallower making difficult for the big ship passing by.
2. 2. The shore line erosion in Hai Hau (Nam Dinh province) has destroyed the sea dyke built in 1940 and exposed the clay deposit containing peat and mangrove wood remain dated about 500 years.
3. Erosion taken place in central Vietnam has destroyed the old coastal sandy bars along the coastline, disappeared the place deposit body and increased the treat on flooding in coastal plains.
4. The tidal-dominated regime has increased the rate of salinization in Ca Mau plain.

In order to prevent the geo-hazards and maintain rational exploitation of natural resources in the coastal zone, attention of the first priority now is the national and international co-operation in project management and sustainable development in coastal zone.

History of global sea level change in quaternary

In general, in Quaternary period there were 4 glacial periods namely Wurm, Riss, Mindle and Gunce and 3 in between glacial periods and between them occurred interglacier (Gunce - Minndle, Mindle - Riss, Riss -

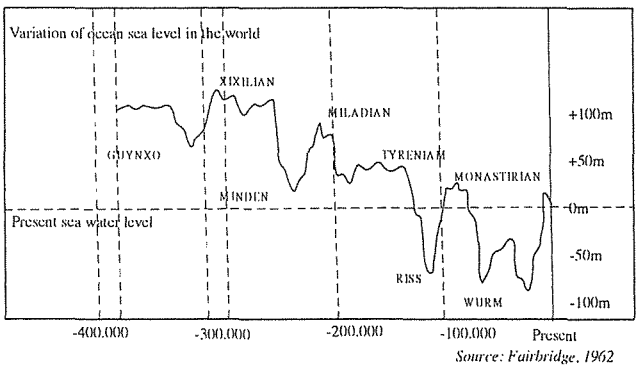


Figure 1. The sea water fluctuation during Quaternary period

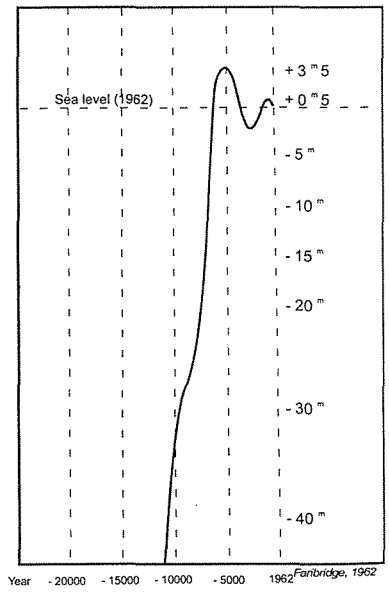


Figure 2. Flandrian Trangression

In Vietnam, sea level change during Quaternary period could be summarized in the following main points:
1. The sea level change has occurred in 5 cycles during Quaternary with 5 alternative phases of regression transgression (Tran Nghi, 1991).

2. The sea level of the latest glacier occurred in late Pleistocene is lower than present one about - 110 m, causing by the lowering the ocean bottom (absolute drawdown). However, the climate change during this time has caused the glacial and interglacial periods.

3. The last transgression after Wurm glacier started from 17.000 - 18.000 years ago. At the beginning, the rate of the transgression was rather fast (9m/ 1000 years). From 6000 - 7000 years BP, the sea level has rather slower increased. Finally, the sea level has reached maximum transgression for 6000 years BP.
Due to the slow down in rate of seawater rise and magnitude of tectonic movement in some places was very high. Many water level marks and the old sea terraces could be found in many places along the present coastline.

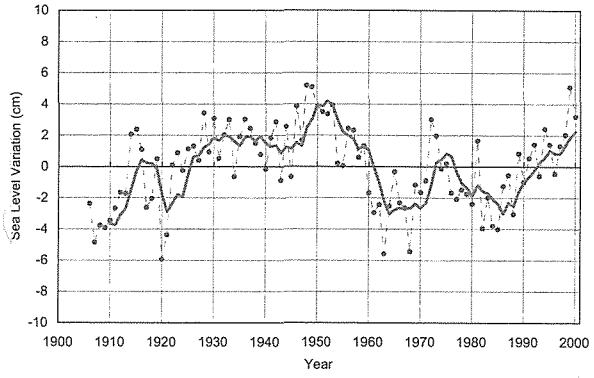


Figure 3. The principal component of sea level variation of 5 stations in Japan

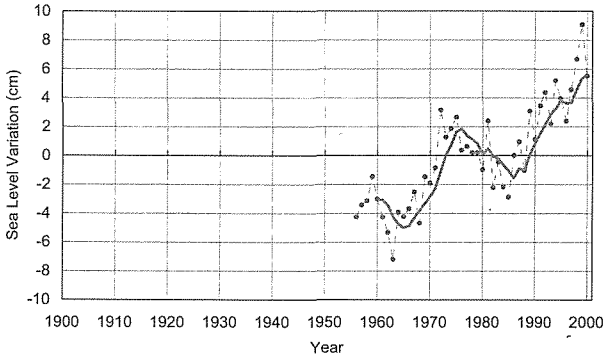


Figure 4. The principal component of sea level variation of 26 stations since 1955 in Japan

The tendency of the sea level rise in the world

Basing on the study results of IPCC during 1990 - 1992, the fluctuation of sea level will be as follow:
a) In future the tendency of sea level rise will increase from 3 - 10 times in comparison with present value.
b) According to the IPCC Scenario, the sea level rise in the world will be as follows:

Table 1. Estimates of Global Sea Level Rise from Tide Gauge Records in the World

Sea level rise (mm/yr)	Error (mm/yr)	Data Used (years)	Number of Gauge Stations	References
1.43	±0.14	1881 - 1980	152	Barnett, 1984
2.27	±0.23	1930-1980	152	Barnett, 1984
1.2	±0.3	1880-1982	130	Gornitz & Lebedeff, 1987
2.4	±0.9	1920-1970	40	Peltier & Tushingham, 1989
1.75	±0.13	1900-1979	84	Trupin &Wahr, 1990
1.7	±0.5	N/A	N/A	Nakibouglu & Lambeck, 1991
1.8	±0.1	1880-1980	21	Douglas, 1991
1.62	±0.38	1807-1988	213	Unal & Ghill, 1995

Table 2. The forecast sea level rise in the world

Scenario	Proposed Sea Level Rise (cm)	
	in 2030	in 2100
IPCC (1990)	8 - 29	33 - 110
IPCC (1992) using technology of MonteCarlo (1% Possibility)	40	160

c) For South East Asian region:
Basing on the CSIRO's scenario (1992), the tendency of sea level rise in the next decades as follows:

Table 3. Forecast sea level rise for Southeast Asian

Year	Amount of Sea Level Rise (ΔH)		
	Low case	Medium case	High case
2010	3	9	15
2070	15	45	90

d) According to EPA (10/1995), the amount of sea level rise with reach about 15cm (2030) and 34cm (2100) but with 10% probability it will increase 30cm (2050) and 70cm (2100).
e) For Viet Nam
Basing on analysis available data collected for the past 30 years, the average rate of sea level rise in two bigger deltas (Red River and Mekong River) is about 2 - 3mm/year. It is corresponding to the mean world's sea level change.
The proposed rates of sea level rise according to CSIRO's (1992) as well as IPCC's (1990, 1992) scenario are as follow:

Table 4. Rate of sea level rise by the year of 2100

Sea level in 1990		Amount of sea level rise (cm)					
		2000	2010	2030	2050	2070	2100
The same rate as past period	Ho (Average value)	2-3	4-6	8-12	12-18	16-24	22-33
High rate according to CSIRO' scenario	Ho (High value)	6-9	12-18	24-36	36-54	48-72	66-99

Note: The figure must be calibrated with geo - dynamic condition and the rate of water withdrawn in a big city.

In short, in the coastal zone of Viet Nam the expected rate of sea level rise will be 30cm/year (low case) and about 100cm (high use) in the year of 2100. However, the process of sea level rise will be gradually taken place with average rate of 6 - 10 cm per a decade.

Sea level rise and its possible impacts in Vietnam

Sea level rise
According to the measured data at Hon Dau station the rate of sea level during 1978 - 1997 was about 2mm/year (fig 5).

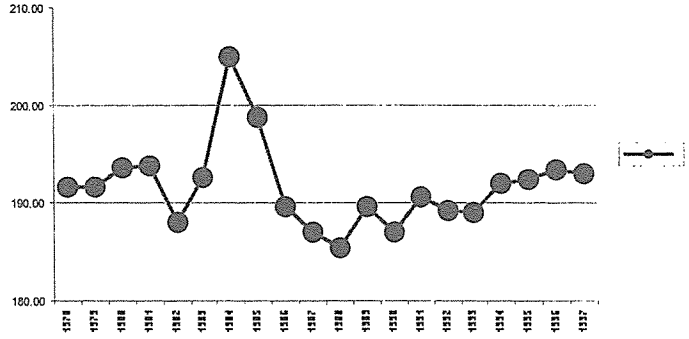


Figure 5. The principal component of sea level variation In Hon Dau station

Determination of Flooding Area

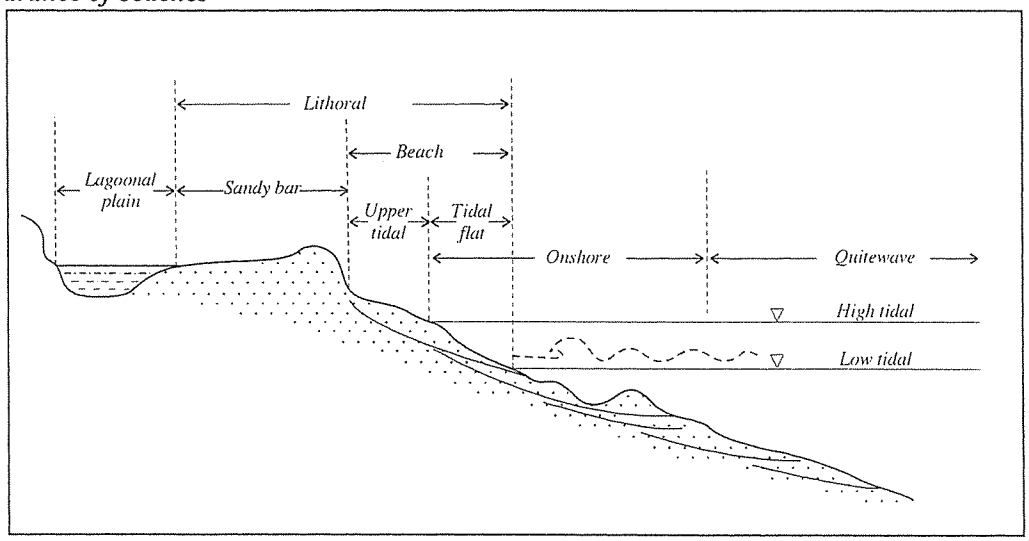
According to the CSIRO's scenario, by the year to 2100 the flooding area in the Red river delta will reach 330000 ha comprising about 172000 ha of rise field; 30000 ha of residential area; 19000 of salt production field and 97000 ha of land of other use. The percentage of flooded area per total area of some provinces in coastal zone of northern part of Vietnam is shown in table 5 and figure 7.

Table 5. Amount of flooding area in the year of 2100 - 1m height of sea level rise in the Red River Delta (Nguyen Ngoc Thuy, 1995)

No	Province	Amount of flooded Area	
		Area (km^2)	% of total area
1	Hai Phong	581,67	3,86
2	Thai Binh	1602,26	10,72
3	Nam Ha	823,21	5,39
4	Thanh Hoa	177,81	1,60

In the southern past, because of the lack of available data (topographical map of large scale) in amount of the territory the flooding area has counted only for Ben Tre province. According to this number, the following area reaches 886,1 km^2 taking up 39,8% of the total area (2225 km^2). By simulation, the lowland area of the Mekong River Delta is approximately 1,57 x 106 ha (15.700 km^2). That is why the total submerged area is about 19000 km^2 (fig 8).

Disappearance of beaches



In Central Vietnam one local effect of increasing relative mean sea level in accelerated coastal erosion. An increase in sea level would result in more severe wave erosion of dunes and beaches and a results and offshore sediment transport to create flatter offshore beach profile. Finally, this result would be a diminishment of local beach environments as sand sediments are transported offshore beyond the depth at which they participate in seasonal onshore - offshore sediment cycles (fig 6, 7)

Figure 6. Sedimentary Section of Shoreline in Central Vietnam

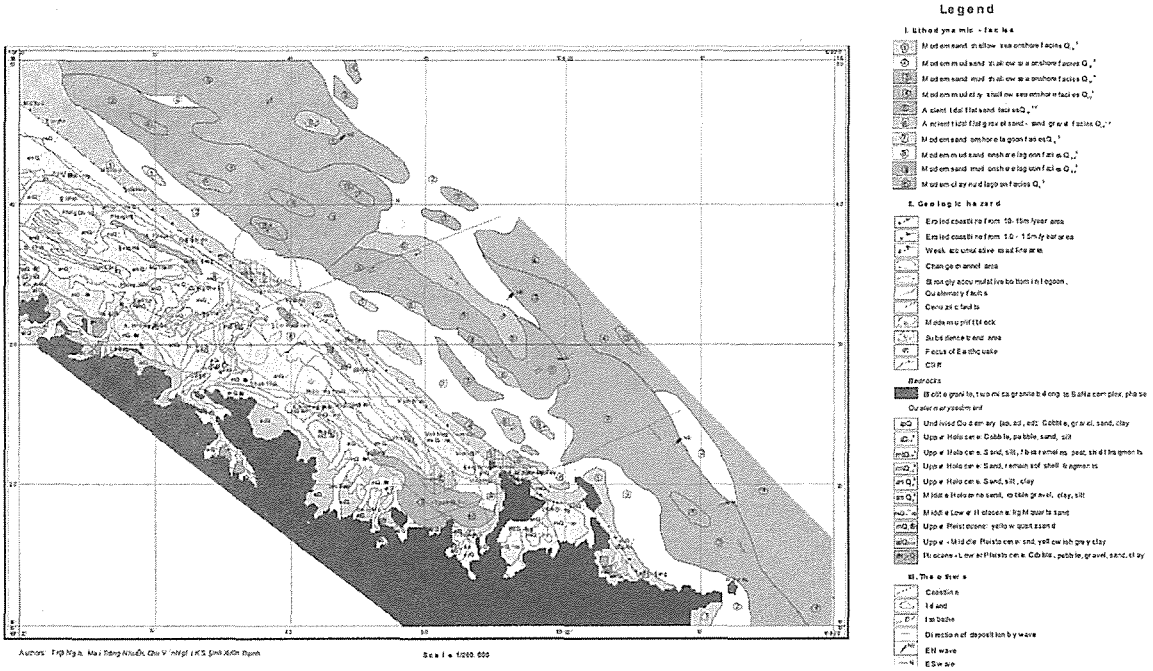


Figure 7. Map of lithodynamic - geologic hazard in Thua Thien - Hue coastline area

According to the high scenario (1m sea level rise) almost beaches along the coast such as: Bai Chay, Do Son, Sam Son, Dong Hoi, Dong Ha, Sa Huynh, Nha Trang, Vung Tau...etc will be submerged in sea water.

Salt - water intrusion

The boundary between fresh and brackish water in aquifers will have major adverse impact on coastal population centers, which often rely on groundwater for drinking water. Secondly, a saltwater wedge of bottom marine water will intrude a greater distance upstream in estuaries. The end result will be an inland intrusion of marine or brackish water zone.

On the effect of salt water intrusion in 1m sea level rise, the following city, town and region will bear severe effect: Hai Phong city, Diem Dien port, Thai Thuy, Tien Hai towns, Con market (Nam Dinh province), Dong Hoi, Dong Ha town, Nha Trang city etc. (Fig 8)

The salt intrusion in the Central Vietnam has made difficulty for drinking production in Hue City (June - July, 2002), Ninh Thuan (June - August, 1995). At that time the price of drinking water has sharply increased (15.000/m3)

Beside the negative effect such as salt intrusion, we must take the advantage of the positive of sea level rise for the social - economic development in the following field:

- Development of mangrove forest.
- Aquaculture (braking shrimp growing).
- Growing sedge for met making

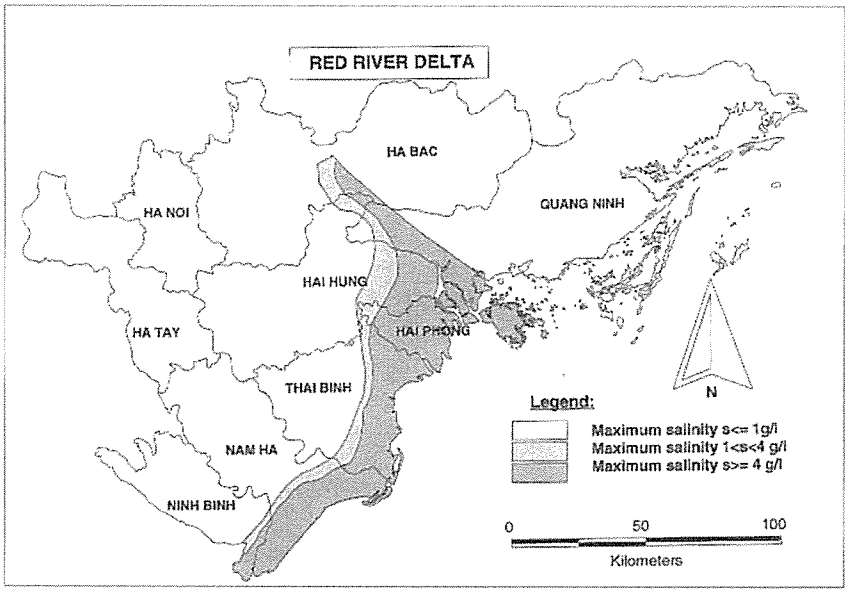


Figure 8. Schema of salinity in coastal zone of Red River Delta

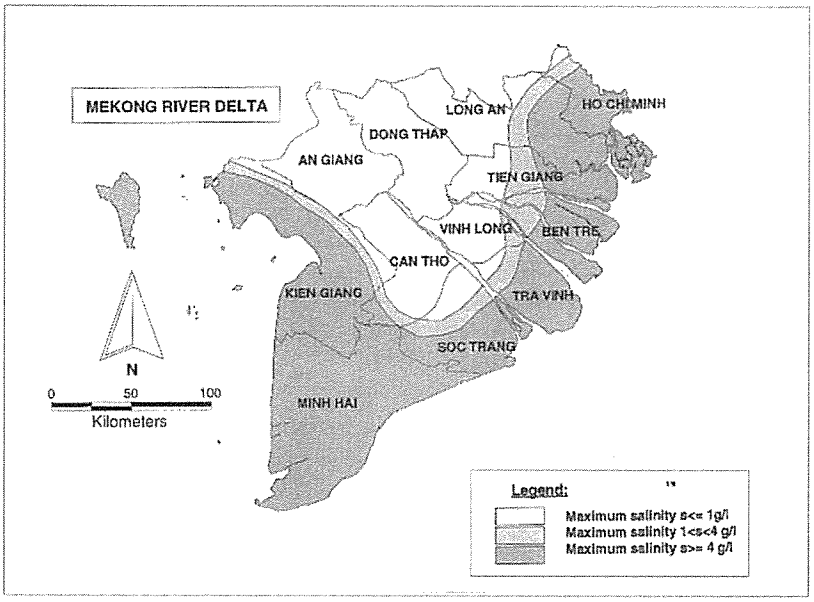


Figure 9. Schema of salinity in coastal zone of Me Kong river delta

Shore line erosion

The study on erosion along the coastline has showed the shoreline erosion has taken place in almost areas along the coast, although with different rate and intensity. Intensive erosion took place along the coast of Red River delta, Mekong River delta. The most stable shorelines are Mong Cai - Hon Gai, Rach Gia - Ha Tinh and Southern coastline of Central Vietnam.

At present time, more than 240 areas along the coastline of Vietnam are under erosion. The erosion is taking place in almost different types of shorelines structure such as rocky shoreline, shoreline compressed of gravel, sand, silt and clay.... However, intensive erosion has taken place in shoreline area composed of

sandy material. In so areas, the erosion is still going on after the prevention measures has been implemented (such as dyke, masonry, plantation...)

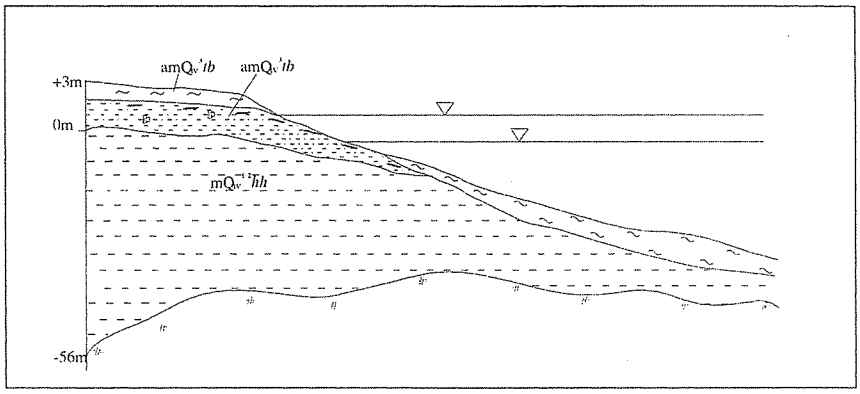


Figure 10. Schema of sedimentary geological section in Hai Hai shoreline area

The erosion coast of more than 1km in length hold 50% the total areas (>120 areas), while in 20% of the total area (50 areas) the shoreline has moved towards the mainland more than 500m (Fig 10).
If consider the rate of the erosion, the erosion of shoreline can be divided into following groups slow (<5m/year) and very intensive (>30m/year). Thus, in 1992 along the whole coast 78 location (≈32%) the erosion took place with the intensive and very intensive rate (Tab. 3).

Table 6. Classification of Erosion along the coastline of Vietnam (*Source: Pham Van Ninh and et al. Etc)*

Intensity of Erosion								**Rate of Erosion**			
Length of Cost				Distance towards land				Type	m/year	No of Area	%
Type		No	%	Type		No	%				
Short	<200	20	10.8	Weak	0-20	39	17.8	Slow	<5	84	39.6
Significant	200-1000	69	37.2	Significant	20-100	55	25.1	Average	5-10	60	28.3
Average	1000-2000	35	18.9	Average	100-200	36	16.4	Intensive	10-30	39	18.3
Long	2000-6000	51	27.5	Strong	200-500	46	21.0	Very intensive	>30	29	13.6
Very long	>6000	10	5.4	Very Strong	500-1000	28	12.7				
				Extremely strong	>1000	15	6.8				
Σ 185 areas			100	Σ 219 areas			100	Σ 212 areas			100

The recent study of the Hai Phong Institute of Oceanography showed that in the northern past of Vietnam (from Mong Cai to Hau Loc). Length of the erosion coast reaches 114km with average rate 6.0m/year in 51 locations (Table 6, 7).

Table 7. Number of Eroded Locations, their length and average rate (Racing 1990 - 2000).

No	Area/Location	Length of erosion (m)	Rate of erosion (m/year)	Number of Eroded Location
I.	Mong Cai - Cua Luc			
	Sub Total	44565	3.1	
1.	Tien Toi	4000	5.3	30
2.	Quang Phong	2200	7.0	
3.	Thon Dong (NW0)	1380	8.0	
II.	Cua Luc - Do Son			
	Sub total	43920	4.4	
1	Dinh Vu	3000	8.6	15
2	South Cat Hai	6400	12.9	
2	Phu Long	3300	9.6	
III.	Do Son - Ba Lat			
	Sub total	2700	9.1	
1.	Thuy Xuan	1800	10	3
2.	Dong Long	400	10	
IV.	Ba Lat - Lach Truong			
	Sub total	22.750	14.3	
1.	Hai Hau	17.200	14.5	
2.	Nghia Phuc	550	11.8	3
3.	Hau Loc	5000	13.9	
Total		113.930	6.0	51

The impact of sea level rise of Vietnam

With 1m sea level rise the following impact will occur when no protective measure will be taken place:
a. The impact is not limited to a narrow coastal zone, but will be more serious further in land.
b. About 40.000 km^2 will be flooding annually.
c. About 17 millions of people (14 millions in Mekong River Delta) will be subjected to annual flooding.
d. About 1700 km^2 (60% total coastal wetlands) will be affected and threatened by sea level rise, especially Minh Hai and Vung Tau - Ho Chi Minh city as well as Xuan Thuy mangrove area because they can not migrate landwards (Because of sea dyke and shrimp ponds...)
e. Additional pumping station and dyke raising will cost at least 2,4 billion USD.
f. About 17 billion of capital value will be lost by the annual flooding (comprising 80% of year GDP)
In short, people habitats and capital investment in the low-lying area in Vietnam are presently at high risk. The impacts of sea level rise will make more pressing situation. Appropriate measures need national and international co-operation.
Proposed integrated coastal zone management
Why need integrated coastal zone management (ICZM). It will help to resolve coastal development issues such as:
- Habitat loss
- Quality of terrestrial and aquatic coastal ecosystem
- Hydrological changes
- Responses or adaptation to sea level rise and other effect of global change.
Implementation of ICZM.
1) Legal and organization implementation
- Apply legislation governing specially activity and development in coastal zone
- Better understanding coastal and coordination of effects
- Increasing low degree consensus and solution of lower authority level
2) Increasing the capital spent on coastal zone defenses in order to improve safely level in coastal zone for people and infrastructure and industrialization.
3) Improve and built new pumping station and sea dyke protection.

4) Training in required to improve knowledge of coastal zone processes and coastal zone protection methods. In fact, the high level of organizational ability, awareness and motivation among coastal authority and specialist presents authority for good implementation.
5) The need to raise houses, particularly in the Mekong Delta, to raising embankments to protect the crop.

Conclusion and proposal

1. The sea level rise in Vietnam has tendency to increase with average rate of 2 mm/year.
2. Sea level rise makes completely influence to coastal zone causing change shoreline (erosion, accretion), filling river channel salinization etc.
3. Erosion and accretion along the seacoast of Vietnam has strongly occurred in different types of geological formation as the result of sea-land or river-sea interaction.
- Big accretion has occurred in two main deltas: Red river delta and Mekong river delta. Sustainable development on landuse and mangrove must be paid in the first priority attention.
- Erosion has been occurred in the whole coast line, but the strongest erosion has taken place in Bach Dang estuary, Hai Hau shore line (in the North), Central Vietnam, Ho Tau, Rach Goc (in the South).
4. Erosion has seriously caused the following effect:
- Destroying civil construction and infrastructure
- Losses due to increased beach and foreshore erosion
- Salinization increasing particularly in Bach Dang estuary, Ca Mau peninsula.
5. Proposed measures for prevention of Hazard.
- Plantation in sand dune area along coast line
- Prohibit sand exploitation in sand beach
- Strengthening sea dyke system by concrete reinforcement (minimum wide: 8 m, depth of foundation: 10 m and slope 1:1 towards sea.
- Flooded and salinized area subjected to be changed for aquaculture development.
- Area rich in heavy metals (inmenit placer) must be exploited before erosion occurring.

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