
Geo-environment and effect of sea level rise in the Chao Phraya Delta

Masatomo Umitsu¹

Abstract: Landforms and sediments of the Chao Phraya Delta are analyzed, and the effect of future sea level rise in the delta is discussed in relation to the geo-environment. Landforms of the Chao Phraya Delta are classified into the deltaic floodplain in the north, the deltaic plain in the central and south, and the tidal plain in the southernmost regions of the plain. Elevation of the tidal lowland in the southernmost region is around 1 m a.s.l., and its surface is very flat and low. Most of the region is originally lower than high tide level, and the sediments of the region are thin tidal flat silt or clay over thick marine sediments. The deltaic plain with elevation 2-3 m has been formed as a tidal and deltaic plain since the Holocene high stand around 6000 years BP. The surface sediments of the region which cover marine sediments are soft silt and mostly consisted as tidal flat origin. There are a little fluvial landforms and their sediments in the deltaic plain. Fluvial landforms as natural levees and flood basins develop in the region of deltaic fluvial plain. Surface sediments of the region are characterized with fluvial silt or clay that cover tidal silty sediments.

The tidal plain of the delta is the region where the direct impact of the sea-level rise may occur. Coastal erosion is already in progress, and there is a possibility of submergence of the region according to the sea level rise. Acceleration of badly drainage condition is anticipated in the deltaic plain, because the surface gradient of the region is very low and the relative gradient of the drainage is going to decrease according to the sea level rise. As there is a little relief in the deltaic plain region except the artificial reclaimed land, the impact of sea level rise might effect widely. Land subsidence of the region also accelerates the effect of sea level rise. In the deltaic floodplain, difference of flooding condition can be seen in relation to the micro landforms. Natural levees and other higher places suffer a little flooding or escape from floodings. On the contrary, swampy areas of a flood basin suffer severe flooding. Most of them develop in the area surrounded by natural levees. The flooding condition has possibility to be accelerated according to the future sea-level rise.

1 Introduction

There are various landforms and coastal environments on the coasts of the Asia-Pacific region (Bird, E. C. F. and Schwartz eds., 1985). Among those landforms, deltas are one of the most important landforms for the life of people in Asia. As the characteristics of deltaic landforms are low and flat, they will be easily affected by future sea-level rise (Milliman, J. D.

¹ Dept. of Geography, Nagoya University, e-mail: umitsu@lit.nagoya-u.ac.jp

and Haq, B. U. ed., 1996). Especially, the effect of the sea-level rise is considered not only as direct coastal erosion and submergence but also indirect effects such as flooding, salinity problems so on.

Many efforts have been made to protect coasts against cyclones, coastal erosion and so on during the historic period. But the result is different in each region according to the historic and socio-economic backgrounds.

Regional characteristics of coastal regions are also related to historic background and socio-economic conditions of each region. It is very important to clarify the regional characteristics of the changing coastal region and evaluate the affect of future sea-level rise (UNCRD/CIRDAP, 1992; Warrick, R. A. and Ahmad, Q.K. ed. , 1996).

It is especially important to clarify the regional characteristics of the deltaic regions and consider the effects of sea-level rise in Asia, because the population dense is and economic activity is great in the deltaic regions.

In this paper, effects of sea-level rise in the Chao Phraya delta are discussed in relation to regional geo-environment.

2 Geo-environmental classification of the delta

The Chao Phraya delta is located in central Thailand, and draining into the Gulf of Thailand. Geomorphologic boundaries between the Holocene alluvial surface and older surfaces are relatively clearly shown in Satellite images (Landsat TM, JERS-1, MOS-1), and it is almost along the inner limit of marine or tidal flat sediments. Landforms of the Chao Phraya Delta are classified into three regions: the deltaic floodplain in the north, the deltaic tidal plain in the central and south, and the tidal plain in the southernmost regions of the plain (Fig. 1).

Elevation of the tidal plain is around 1 m a.s.l., and its surface is very low and flat. Most of the region was originally lower than the highest tide level, and the sediments of the region are thin tidal flat silt or clay over thick marine sediments.

The deltaic tidal plain with an elevation of 2-3 m, has been formed as a tidal and deltaic lowland since the Holocene highstand around 6000 years BP. The surface sediments of the region which cover the marine sediments are soft silt and mostly consist of tidal flat origin. There are few fluvial landforms and their sediments are also rare in the deltaic tidal plain. Fluvial landforms such as natural levees and flood basins develop in the deltaic floodplain. Surface sediments of the region are characterized by fluvial silt or clay that cover tidal silty sediments. Lower deltaic surface along the lower reaches of the Chao Phraya river can be seen in the CORONA Satellite images, and also the well developed natural levees can be seen in the west flank of the deltaic flood plain.

The Holocene sediments in the central plain mainly consist of silt and clay and occasionally organic matter. They are classified into four units: basal peat, marine, tidal and fluvial units from the lower to the top horizons. Radiocarbon ages of the basal peat and mid-Holocene tidal sediments show approximate former relative sea-level change.

The maximum height of the sea-level was higher than 2 meters above the present sea-level, and was recorded at around 6000 yrBP. As shown in Somboon (1990), Holocene transgression extended towards the region around Ayutthaya, 100 km from the present coast, and most of the Chao Phraya Delta was submerged according to the transgression. Late Holocene tidal sediments develop in the central and southern parts of the plain, and they show that the plain expanded according to the retreat of tidal plain towards the south. Slight regression can be seen around ca 4,500 yrBP. Late Holocene tidal sediments develop in the central and southern parts of the plain, and they show that the plain expanded according to the retreat of tidal plain towards the south.

3 Impacts of sea level rise to the Chao Phraya delta

Effect of the future sea-level rise is one of the serious problems in the low and flat deltaic regions of Southeast Asia, and the issues of sea level rise are also being considered in the Chao Phraya Delta (Somboon, J. R. P. and Thiramongkol, N., 1993; Sabhasri, S. and Suwarnarat, K., 1996). Geo-environments of the Chao Phraya delta are very susceptible to sea-level rise. It is assumed that sea-level rise influences the regions of the delta in various ways.

Elevation of tidal plain is 1-2 m and the sediments of the area consist of very soft silt or clay. This elevation is almost the same as the high tide level of the Gulf of Thailand.

In some places, land was reclaimed 1-2 m over the original surface, but most area of the tidal plain is not reclaimed and is used as aquacultural ponds and salt pans.

In particular, the embankments that are surrounding the tidal plain are low and weak condition, and they are vulnerable to coastal erosion.

Actually, in the western part of the Chao Phraya river mouth, rapid coastal erosion is now going on, and protection for coastal erosion in the area is not enough (Vongvisessomjai, S. et al, 1996). If sea-level rise occurs in the future, severe coastal erosion will be the most serious problem in the area. Even if sea-level rise is less than 50 cm, horizontal retreat of the shoreline will be a considerable distance from the present coast. Under the weak protection for the coastal embankment, coastal erosion may progress very rapidly. Soft silt and clay deposits of this area also accelerate rapid erosion.

On the other hand, the area of deltaic tidal plain is located on the inner side of the delta, but the area is also low-lying and has little relief. This environment will also be easily affected by sea-level rise. Serious subsidence has occurred in this area, and the current ground level has been lowered to 1 or 2 m (Photo 1). In several places, the ground level is lower than present mean sea-level. Therefore, drainage condition of the area have become very poor, and flooding may occur easily in the rainy season.

Somboon, J.R.P. and Thiramongkol, N. (1993), Nutalaya, P. (1996), and others have already discussed land subsidence of the area, and they also pointed out the problem in relation to sea-level rise.

Acceleration of the already poor drainage conditions is anticipated in the deltaic tidal plain because the surface gradient of the region is very low and the relative gradient of the drainage is going to decrease as a result of sea level rise. As there is little high ground in the deltaic tidal plain region except the artificial reclaimed land, the impact of sea-level rise may greatly effect the region. Land subsidence also accelerates the effect of sea-level rise.

Difference in flooding conditions can be seen in the deltaic floodplain according to the micro landforms (Fig. 2, 3). Natural levees, that are slightly higher than the surrounding region, develop along the several river channels in the western flank of the deltaic flood plain. On the other hand, there are a few micro landforms such as natural levees on the eastern flank of the deltaic flood plain, because the area has been cultivated for a long time and the original topography was already changed.

These geo-environmental differences show different flooding conditions. As the original landforms are preserved in the western flank of the deltaic floodplain, the region is easily flooded according to the increase of river discharge. Natural levees and other higher places, however, suffer little flooding or no flooding at all. On the contrary, swampy areas of a flood basin suffer severe flooding. Most of them develop in areas surrounded by natural levees.

On the other hand, settlements in the eastern flank of the deltaic floodplain are located on the fields that are well consolidated for arable land. If the drainage condition becomes poor, broad areas of the eastern flank of the deltaic flood plain will deteriorate (Photo 2). The flooding has the possibility to accelerate as a result of future sea-level rise.

4 Conclusion

There are considerable differences in the geo-environment of the Chao Phraya delta, and the effects of sea-level rise will cause these areas to react differently. If the prompt measure is not taken for the sea-level rise, the following effects may happen in each region.

In the region of tidal lowland along the present coast, vulnerability is characterized by coastal erosion and submergence of low-lying tidal land. Low elevation of the tidal delta caused by land subsidence may easily be affected by floodings and the condition will accelerate in response to the sea-level rise.

In areas of further inland on the deltaic floodplain, the contrast of geo-environment can be recognized in eastern and western flanks in terms of land consolidation. If the drainage function is not enough against the sea-level rise, the eastern flank might become a broad poor drainage area. On the other hand, most natural levees are free from floodings in the western flank of the deltaic floodplain. Serious problems may occur in the part of flood basin surrounded by natural levees..

Further examination should be undertaken using estimation of sea-level effects based on the combination of geo-environmental and socio-economic conditions.

Acknowledgement

The authors would like to express our sincere gratitude to Mr. Sin Sinsakul, Mr. Suwat Tiypairach and Dr.Niran Chaimanee for their kind support to my fieldwork in the Central plain. JERS-1 data are used under the permission of RESTEC.

References

- Bird, E. C. F. and Schwartz eds. (1985) *The World Coastline*. Van Nostrand Reinhold Company, New York, 1071 pp.
- Milliman, J. D. and Haq, B. U. ed. (1996) *Sea-level Rise and Coastal Subsidence*. Kluwer Academic Publishers, 369pp.
- Nutalaya, P., Young, R. N., Chumnankit, T. and Buapeng, S. (1996) Land subsidence in Bangkok during 1978-1988. in Milliman, J. D. and Haq, B. U (eds.) *Sea-Level Rise and Coastal Subsidence*, 105-130.
- Sabhasri, S. and Suwarnarat, K. (1996) in Milliman, J. D. and Haq, B. U (eds.) *Sea-Level Rise and Coastal Subsidence*, 343-356.
- Somboon, J. R. P. (1990) *Geomorphology of the Chao Phraya delta, Thailand*. Ph.D. Thesis, Kyoto University, 86 p.
- Somboon, J. R. P. and Thiramongkol, N. (1993) Effect of sea-level rise on the north coast of the bight of Bangkok, Thailand. *Malaysian Journal of Tropical Geography*, 24, 3-12.
- UNCRD/CIRDAP (1992) *Development of Modules for Training on Integrated Approach to Disaster Management and Regional /Rural Development Planning*. UNCRD-CIRDAP workshop and seminar, Phase III, vol. II, 334 pp.
- Vongvisessomjai, S. et al, (1996) Coastal erosion in the Gulf of Thailand. in Milliman, J. D. and Haq, B. U (eds.) *Sea-Level Rise and Coastal Subsidence*, 131-150.
- Warrick, R. A. and Ahmad, Q.K. ed. (1996) *The Implications of Climate and Sea-level Change for Bangladesh*. Kluwer Academic Publishers, 415 pp.



Photo 1
Land subsidence in the suburbs of Bangkok



Photo 2
Poor drainage area of the deltaic
floodplain in the Chao Phraya delta

Figures

FIG. 1 LANDFORM CLASSIFICATION MAP OF THE CHAO PHRAYA DELTA

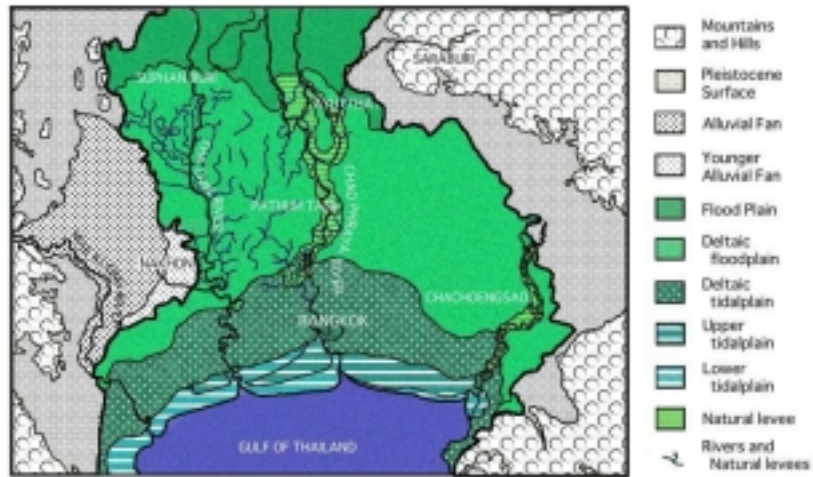


Fig. 2
JERS1 satellite image of the eastern flank of deltaic floodplain in the Chao Phraya delta.



Fig. 3
JERS1 satellite image of the western flank of deltaic floodplain in the Chao Phraya delta.

