BEACH NOURISHMENT AS AN ADAPTATION TO FUTURE BEACH LOSS DUE TO SEA LEVEL RISE IN THAILAND

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Introduction

The global sea level rise and climate change can result in coastal erosion and cause a serious problem for the population at the low-elevated coastal area (Ranasinghe *et al*., 2012). To present, Ritphring *et al*. (2018) projected the sandy beach erosion due to the future sea level rise for all the Thailand's coastlines based on 4 Representative Concentration Pathway (RCP) scenarios and suggested that, Thailand may loss 46-72% of the existing beach areas.

The beaches in Thailand function as recreational purposes (e.g. tourism) and serve as disaster prevention areas. Therefore, those beach areas deserve essential preservation. Yoshida *et al*., (2014) proposed a framework for beach nourishment as an adaptation to beach erosion induced by sea level rise for the entire Japanese's coastlines and it targets to specify vulnerability of beach areas and estimates the sand volume and costs to maintain beach width in terms of different beach functions. Since there is no adaptation plans to deal with the future sea level rise in Thailand. This study aims to develop estimate the sand volume and costs by using Yoshida method for the further adaptation framework preparation.

Study area

Thailand coastlines compose 51 sandy beach zones a. By overall, sandy beaches in Thailand has a small beach width with entirely-averaged of 34.8 m. The beaches have averagely 0.3 mm of sand diameter and the beach slopes range between 1-14 degrees.

Methodology

The beach nourishment volume calculation in the present study adopted Yoshida's method which stated the optimal nourishment volume was determined based on the concept of the Bruun (1962) rule. The concept of beach nourishment for keeping beach for a design width (Y_*) is shown in Fig. 1. The profile increases by adding sand (B). After the sea level rise, the nourishment can maintain the future beach width to greater than or equal to Y_*. The beach model was based on the assumption of the concept of equilibrium profile (Dean, 1991). Based on that, the sand volume can be calculated by equation (1).

$$V_p = BY_0 + \int_0^{W_*} \left(Ay^{2/3} + B\right) dy - \int_0^{W_*} \left(Ay^{2/3}\right) dy \quad (1)$$

where V_p is the profile change volume (m^3/m), Y_0 is the original beach width, A is scaling parameter, B is the depth of added sand (i.e. the amount of vertical increase of equilibrium profile), Y_*, and W_* is the cross-shore distance to closure the depth h_*. The amount of vertical increase of equilibrium profile B can be determined by equation (2), based on the Bruun equation (Yoshida et al., 2014).

$$B = S - \left(\frac{h_* + B_h}{W_*}\right)(Y_0 - Y_*) \quad (2)$$

where S is the sea level rise, h_* is the closure depth and B_h is the berm height. The amount of sea level rise after beach nourishment causes an allowable retreat (Y_0 -Y_*) after the profile increases the amount of B. The beach data set used in this study were from Ritphring *et al*. (2018)'s study including, sediment size, and beach slope. The calculation assumed that the native sediment size and the filling sediment size are equal and the design width (Y_*) is the beach width at the existing condition of each coastal zone.

Results and discussions

The estimation of the beach nourishment volumes and the costs for each Thailand sandy beach zone are shown

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in Fig. 2 and Fig. 3 respectively. Fig. 2 demonstrates the sand volume required for each zone at each RCP scenarios. By overall, sandy beach zones in the lower part of Thailand need greater amounts of sand than the other parts. It would need a minimum of 193 million m^3 (RCP2.6) to a maximum of 303 million m^3 (RCP8.5) to preserve the existing shorelines in total. According to the Thai government's coastal engineering's project reports, a cubic meter of sand costs approximately 5.5-10.5 USD. Consequently, the costs of beach nourishment could reach 1,062-3,190 million USD to keep the shorelines at the present position for all sandy beach zone as shown in Fig. 3.

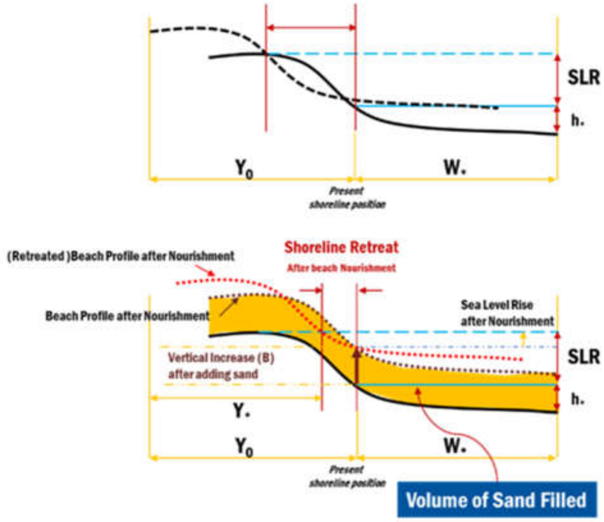

Fig. 1 The concept of beach nourishment for keeping beach width for each option (Yoshida *et al*., 2014)

Conclusions

This study provides preliminary results of sand volume and costs required for beach nourishment for each coastal zone in Thailand for keeping beach width in present condition. It should be noted that this is only one-time nourishment to a future period (2081-2100) and only considered beach erosion by the impact of sea level rise. The construction design of beach nourishment should be assessed in future work. The benefit of the beach is needed to be evaluated to determine optimum beach widths and further cost-benefit analysis is required for realistic nourishment in design practice.

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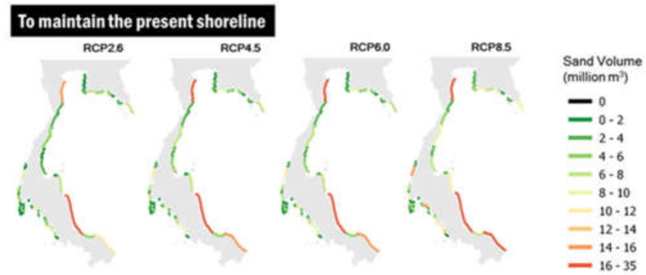

Fig. 2 The total sand volume required for each sandy beach zone for 4 RCP scenarios.

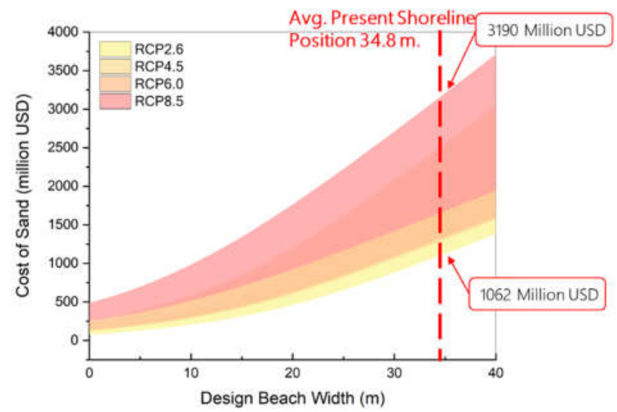

Fig. 3 Costs of sands required for entire coastlines for 4 RCP scenarios.

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