Wind wave effect on tsunami influenced bathymetry at Kirinda Harbor, Sri Lanka

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1.0 Introduction:

Various numerical models have been introduced and used to estimate the tsunami induced bathymetric changes. However, those models yet to be validated due to unavailability of measured bathymetric data immediately before and after the tsunami. Even though there are some bathymetric data which can represent pre and post tsunami conditions, wind wave effect on those data cannot be eliminated. Measured bathymetric data in 2004 November and 2005 February at Kirinda Fishery harbor, Sri Lanka provides us a good opportunity to validate the tsunami sediment transport model.

In this study we used above bathymetries to compare the results of tsunami sediment transport model. As these data also subjected to normal wind wave induced currents during two months after the 2004 Indian Ocean tsunami event, we include the wind wave effect on modeled data before the comparison.

This paper will represent the tsunami effect on a bathymetry and its short term recovery due to wind waves.

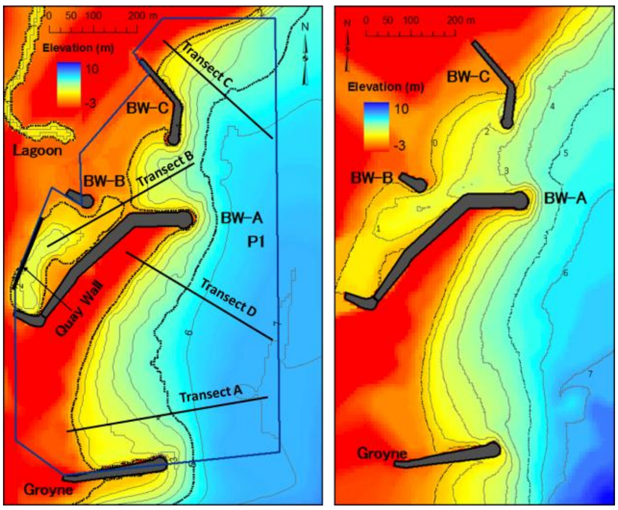

Figure 1: Measured bathymetric data before (left) and after (right) tsunami

2.0 Tsunami Effect and Results Comparison:

The model proposed by Takahashi et al. (2000) was used to compute the tsunami influence in Kirinda bathymetry (Ranasinghe et al, 2012). This model is able to calculate both bed load and the suspended load in order to compute the total bed level change. Model results comparison has been done by considering the bulk volume change in a selected area well as by considering bed level change along four selected transects in greater detail. Tsunami sediment transport model was run up to 360 min after the earthquake and final bed level change is compared with measured data.

The ratio for the erosion and deposition volume for measured data in the selected area is 0.52, whereas the same ratio obtained from the modeled data is 0.54. However, model calculated erosion and deposition volumes are 22% and 10% higher than the measured volumes. Further, correlation coefficients [$(R_T)^2$] obtained for the measured data and modeled data along four transects are not so good at three transects which are facing to the open sea. However, in transects B which represents the harbor mouth shows a better agreement for measured and modeled data.

Therefore, these facts guided us to consider the wind wave effect on Kirinda bathymetry for two months after the tsunami event.

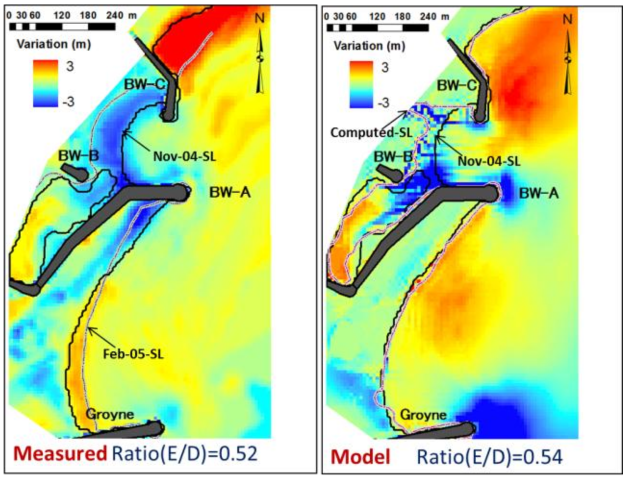

Figure 2: Measured Data (left) and modeled data (right)

3.0 Nearshore Wave Parameters at Kirinda:

In Sri Lanka, nearshore wave climate is influenced by both southerly approaching swell waves and by sea waves which are mainly influenced by monsoonal weather pattern (Ranasinghe and Gunaratne, 2011). Hence, most of the available data can be found as sea and swell separately. However, measured data at Kirinda is limited only for two years period. As seasonal wave climate is very much essential for analyzing the wind wave effect during two months, we used the wave transformation technique to establish the nearshore wave climate at Kirinda. In this method, available wave data in the vicinity has been transformed to Kirinda 15 m depth by considering all four seasons of South West (SW in May-September), North East (NE in December-February), and Inter Monsoon (IM) 1 (in March-April) and 2 (in October-November) and two wave systems (Gunaratne et al.,2011). Wave statistics at Kirinda can be shown as Table 1.

Table 1: Wave Statistics at Kirinda 15m Depth

SEASON	SEA			SWELL		
	Hs/(m)	Tp/(s)	DWD/(ºN)	Hs/(m)	Tp/(s)	DWD/(ºN)
SW	1.00	4.91	235	1.30	12.45	185
IM1	0.69	5.58	115	1.00	11.75	185
NE	0.68	5.07	120	0.68	11.97	185
IM2	0.67	5.73	175	0.94	12.15	185

According to the relative strength analysis of two wave systems for all four seasons we were identified that both wave systems are equally strong in NE monsoon period. Therefore, overall wave conditions were calculated for NE monsoon period by combining the sea and swell wave conditions.

4.0 Wind Wave Model: Simplified overall wave conditions for NE monsoon period and the output bathymetry (20x20m grid spacing) from the tsunami sediment transport model are used as the main inputs for the wind wave sediment transport model. We used the validated model of Nishihata et al. (2009) to compute the wind wave induced bathymetric change. This model is able to calculate the local and alongshore sediment transport rates considering waves and wave induced currents. Sediment particle size is used as 0.2 mm and model has run for two months of period. Hence, output of the wind wave sediment transport model will contents both tsunami and wind wave effects.

Results and Discussion: Figure 3 shows the wind wave induced bathymetric change (During 2004 Dec to 2005 Feb) and total bathymetric change due to tsunami and wind waves (During 2004 Nov to 2005 Feb). It clearly show that bed level change specially near to the shoreline is much similar to measured data which could not be seen in the model results given by the tsunami sediment transport model. As the bed level change on land could not be calculated by the wind wave sediment transport model total bed level change comparison has not been done.

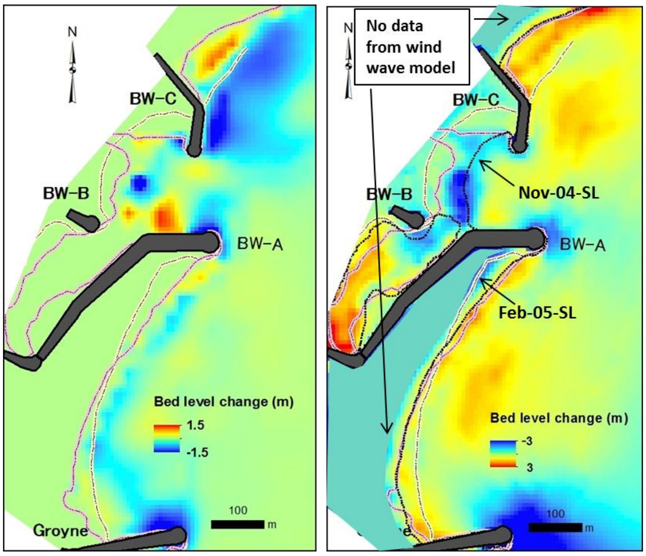

Figure 3: Wind wave induced bathymetric change during 2004 Dec to 2005 Feb (left) and total bathymetric change due to tsunami and wind waves during 2004 Nov to 2005 Feb (right)

However, we did the same comparison on bathymetric change along four transects. As a result, correlation coefficients [$(R_{T+W})^2$] were much improved as shown in Figure 4. Especially at the harbor mouth we can see the better agreement even than before which proved the significance of wind wave effect on tsunami influence bathymetry recovery. Figure 4 shows the bed level change comparison along Transects B and D out of four transects.

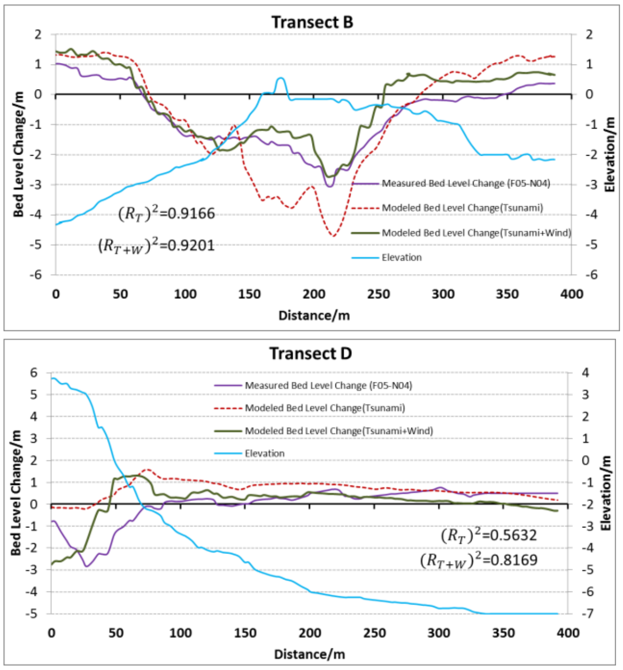

Figure 4: Bed level change comparison along transects B and Transect D

Conclusions: Tsunami sediment transport model results shows better agreement with measured data as far as bulk volume change is concerned. Furthermore, scour at the harbor mouth was well reproduced by the tsunami sediment transport model; whereas it results comparison has given low correlation in the locations where it is open to the sea. However, some local bed level changes that could not be achieved along with tsunami sediment transport model, has been improved when the wind wave effect was included to model data. Finally, it can be concluded that normal wind wave induced sediment transportation played a significant role in short term bathymetry recovery after the tsunami in Kirinda Harbor, Sri Lanka.

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