INVESTIGATION OF SHORELINE CHANGE CAUSED BY THE GREAT EAST JAPAN TSUNAMI 2011 AROUND SAMEGAWA RIVER MOUTH

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The Great East Japan Tsunami 2011 had caused shoreline retreat due to severe erosion, especially in sandy coast. The coastal morphology after the tsunami may not be the same to the pre-tsunami condition. It may cause for the river mouth. Samegawa river mouth area is investigated in this study by analyzing satellite images of pre-tsunami condition, immediately after the tsunami, and most recent condition. The images were digitized and analyzed. It was found that sediment intrusion occurs in the river mouth which may block the nearby drainage system.

Key Words **:** *tsunami, shoreline changes, aerial photograph, river mouth*

1. INTRODUCTION

The Great East Japan Tsunami 2011 had significant impact to the affected coastal area. The wave reached the northern coast of Japan with massive force, causing immense damages. In some places, the run up height reached to about 40 meter (Mori et al, 2012).

Shoreline in Miyagi and Fukushima prefectures were heavily affected by the tsunami. Adityawan et al. (2012) had analyzed the tsunami propagation on land and in river along Sendai plain. Tanaka et al. (2011) had provided report on the tsunami impact in Miyagi coast based on aerial photos. Shoreline retreat due to severe erosion occurred, especially in sandy area. Udo et al. (2011) had shown land subsidence and erosion occurred in the northern Sendai coast area. The coastal morphology after the tsunami was highly unstable. After some period of time, a new balance coastal condition will be achieved. The new coastal condition often different from the pre tsunami condition.

There are cases where the new coastal condition is causing problem for the river mouth, i.e. New Kitakami River. The sandspit in New Kitakami River mouth was reformed in a more upstream location that blocks drainage outlet. A more severe problem occurred in Nanakita River where its river mouth was completely closed and required dredging to re-open (Tanaka et al., 2012). Therefore, it is important to investigate the shoreline change around the river mouth.

Samegawa river mouth area is investigated in this study by analyzing satellite images and aerial photo of pre-tsunami condition, immediately after the tsunami, and the most recent image.

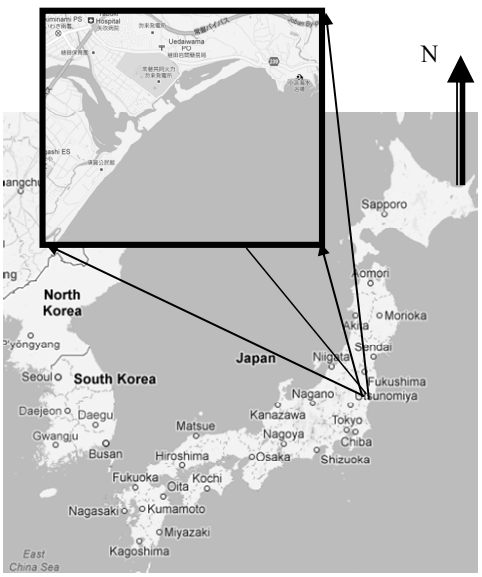

Fig.1 Study Area.

2. STUDY AREA

The study area is coastal area around Samegawa river mouth, Fukushima, Japan as shown in **Fig.1**. It is situated in Nakoso coast, covering approximately 4 km of shoreline facing the Pacific Ocean. The coastline is mostly sandy area. Joban Kyodo Power Plant is located nearby. The discharge from the powerplant is separated with the river discharge by a jetty in the left bank of the river mouth, constructed in 1982. More detail on long-term changes in sand movement for this area can be found in previous study (Sato et al., 2004).

Severe erosion occurred due to the The Great East Japan Tsunami 2011. An outlet of nearby drainage is located around the rivermouth. The drainage system may face some problem in the future due to the sediment intrusion.

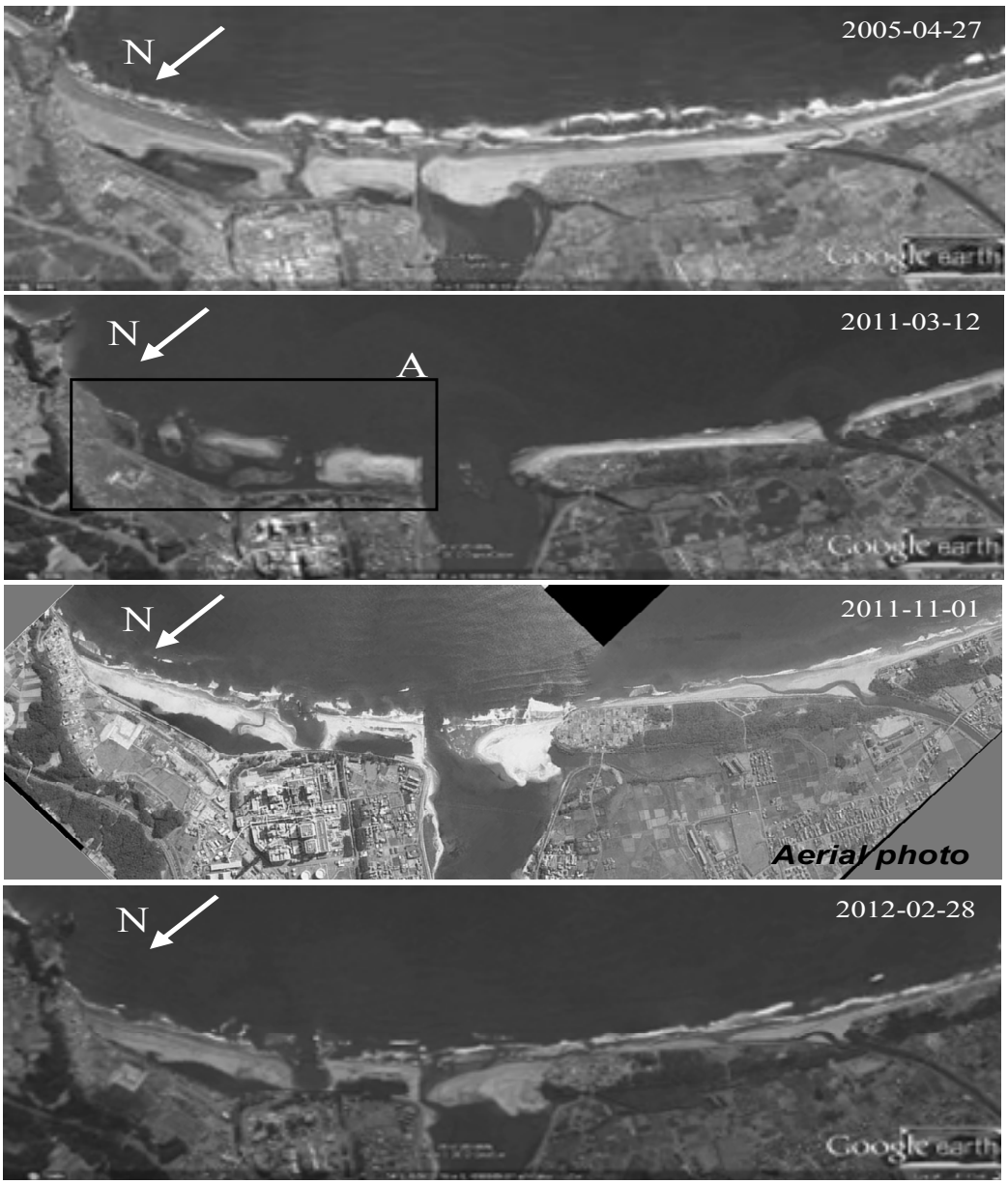

Fig.2 Satellite images.

2011-04-18

2012-06-07

Location: Fig.2-Box A

Fig.3 Shoreline retreat.

3. METHOD

Satellite images and aerial photos have been extensively utilized in shoreline change detection. Pradjoko and Tanaka (2010) had assessed shoreline changes in Sendai coast based on a series of consecutive aerial photos.

Satellite images for the study area were collected from Google Earth for 27 April 2005 (DigiGlobe, resolution 0.6 m), 12 March 2011 (DigiGlobe, resolution 0.6 m), and 28 February 2012 (GeoEye, resolution 0.5 m), representing the condition before the tsunami, immediately after the tsunami, and present. In addition, an aerial photo was acquired showing the condition on 1 November 2011. The satellite images and the aerial photo are shown in **Fig. 2**. Field observation was conducted and photos were taken. **Fig. 3** shows the condition of the shoreline shortly after the tsunami and the most recent condition. It can be seen the retreating and the breaching of the shore line.

The satellite images were acquired in Geographical Coordinate System (GCS-WGS`84). Therefore, rectification process is not required. The coordinate system was directly changed to the Projected Coordinate System (UTM-WGS`84 Zone 54N). On the other hand, aerial photo contains no geo-reference information. Thus, rectification was conducted prior to the analysis. The images were rectified using reference points to the same coordinate system as the satellite images. More detail on rectification method can be found in previous study (Pradjoko and Tanaka, 2010).

The projected images were digitized to obtain shoreline position and protection/structures. A local coordinate baseline was used to quantify the shoreline change. The shoreline change was investigated further by analyzing several cross sections along the coastline.

The accuracy of the digitized map follows the resolution of the source map. However, the satellite images do not contain information on the exact time (hour, minute) when the image was captured. Therefore, it is not possible to provide correction value based on tidal level (**Fig.4**). Nevertheless, maximum error that may occur can be estimated for the particular day (**Table 1**).

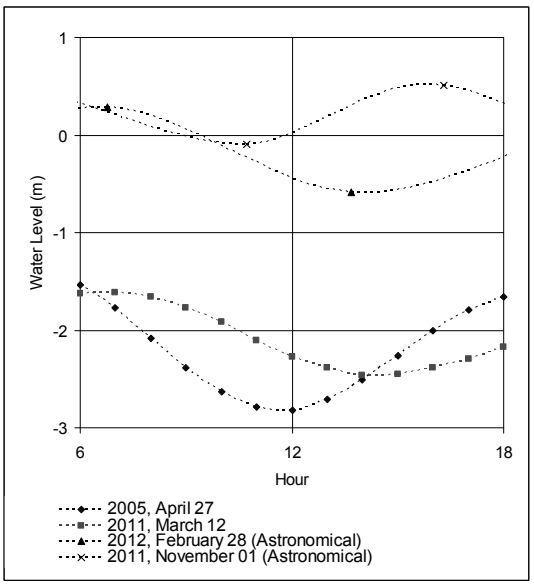

Fig.4 Tidal level.

Table 1 Data accuracy

Image	Spatial Resolution (m)	Possible Tidal Error (Max) (m)
2005, April 25	0.6	28.21
2011, March 12	0.6	24.61
2011, November 01	1.0	7.46
2012, February 28	0.5	5.86

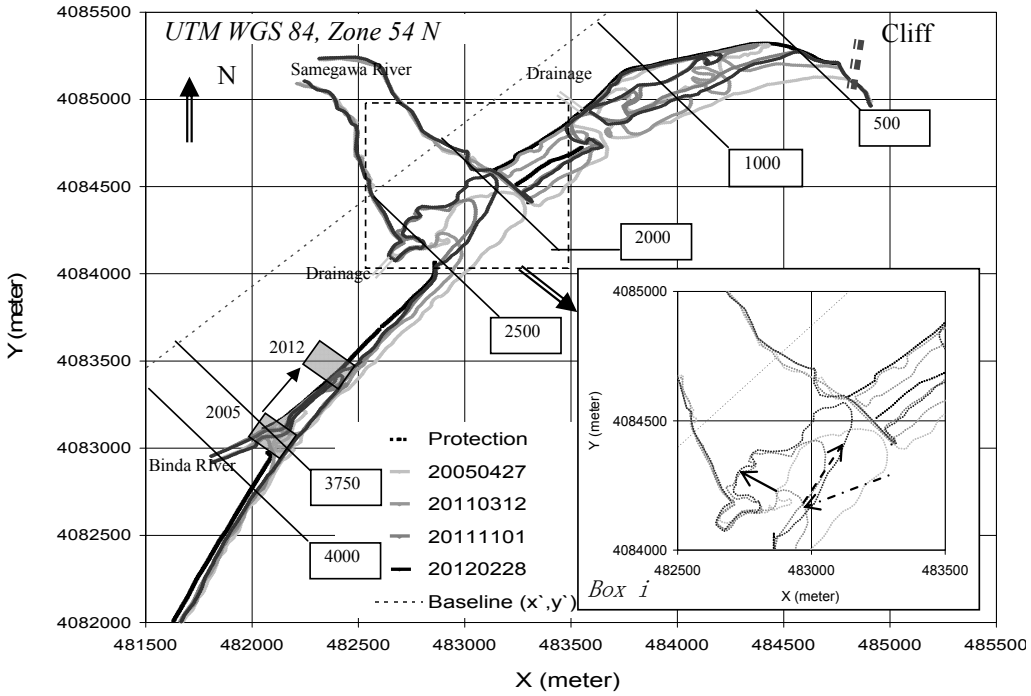

Fig.5 Shoreline detection.

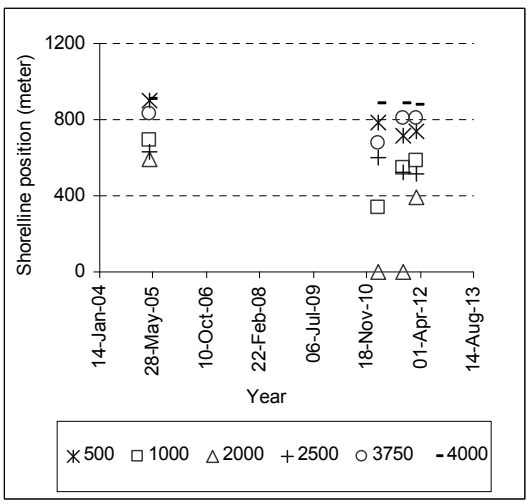

Fig.6 Shoreline temporal variation.

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The maximum error in this study for each images were estimated by analyzing tidal level variation during day time. The error is given by the maximum deviation recorded, converted to horizontal distance using the beach slope. The beach slope is approximately 0.1. The tidal data were obtained from Onahama port. Unfortunately the port was heavily damaged by the tsunami. Water level data right after the tsunami is not available.

4. RESULTS AND DISCCUSSION

The digitized map showing the shoreline detection is given in **Fig. 5**. It is found that the northern part of Samegawa River was severely eroded starting from the river mouth to the cliff due to the tsunami. On the contrary, erosion in the southern part of the river mouth was milder than the northern part. The retreating distance of the shoreline varies as shown in **Fig. 6**. It is shown that the highest retreat occurred around cross section 1000 with the distance of approximately 400 meter. This agrees well to the field observation as shown previously in **Fig. 3**. The erosion in the southern part of the river mouth occurs up to cross section 4000 where no significant changes of shoreline position is found (**Fig. 6**).

A closer look of the Samegawa river mouth (**Fig. 5** box i) shows that the sandspit in front of the river mouth was completely eroded by the tsunami.

The newly formed sandspit is located around 100-200 meter (**Fig 6**. cross section 2000 and 2500) more upstream of the pre-tsunami condition. This may cause some problem since it may block the nearby drainage outlet. Moreover, the protection at cross section 2500 now becomes the shoreline without any buffer from sand deposit. It was also found that the Binda river mouth was eroded after the tsunami (**Fig. 6** cross section 3750), and the new river mouth moved further north due to the elongated sandspit (Fig. 5).

5. CONCLUSSIONS

This study provide valuable information which will be very useful for restoration process as well as future disaster prevention. Overall, it was found that after the tsunami until present, the southern part continues to erode while deposition occurs in northern part.

The elongated sand spit in Binda river mouth and the retreat of sand spit in Samegawa river mouth occurs due to natural process in achieving a new balance condition. The general sediment movement in this area occurs from south to north. Therefore, the northern part will draw sediment from the southern part up to an equilibrium point, which is approximately around cross section 4000.

As the sediment moves north, it will pass the Samegawa river mouth and fill the upstream part first since the river mouth bed was quiet deep due to the tsunami. On the contrary, Binda river river mouth depth is much lower than Sameagawa river mouth, hence the elongated sandspit.

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