STUDY ON THE RELATIONSHIP BETWEEN TOPOGRAPHY AND SAND RIPPLE FORMATION AREA ON TIDAL FLAT

Toyohashi University of Technology, Student Member, Siti Afifah Binti Azmi, Hafizi Bin Mohamed
Toyohashi University of Technology, JSCE Member, Shigeru Kato, Masaya Toyoda

1. Introduction

Tidal flats are coastal wetland that form in intertidal areas where sediments have been deposited by waves, currents, tides, or rivers. The mud of the tidal flat is characteristically rich in dissolved nutrients, plankton and organic debris and it supports large numbers of benthos. Therefore, they play a critical role in coastline protection and biodiversity conservation[1]. Sand ripples are known as a minor topography that contributes to a major topographical change of this tidal flat. Hence, a sand ripple distribution in tidal flats must be constantly monitored and precisely mapped with the aim of a better understanding of coastal environments. Several studies related to the formation of sand ripples using remote sensing techniques have been conducted in combination with field surveys[2]. However, the study focusing on the correlation between topographical changes in tidal environments related to sand ripples distribution is still lacking. Therefore, in this study we investigated the changes of sand ripples distribution area and its direction with the topography conditions such as ground level and level changes of Maeshima Tombolo tidal flat using UAV (Unmanned Aerial Vehicle) photogrammetry.

2. Method

2.1 Field survey

The aerial surveying was carried out on 21 August 2020 and 23 August 2021 at a 500 m-long tidal flat called Maeshima Tombolo tidal flat located in Nishio city of Aichi prefecture in Japan facing Mikawa Bay (**Figure-1**). The images were vertically taken using DJI Phantom 4 Pro and Phantom 4 RTK UAV (Unmanned Aerial Vehicle) 50 m from the ground.

2.2 Image Processing

In this study, the main objective of this image processing was to extract the information related to sand ripple patterns from the images taken during aerial surveying. **Figure-2** is the flow chart of the image processing and analysis to produce the processed image showing the sand ripple direction. For image enhancement and filtering, Sobel filter and High-pass filter were compared based on a few image conditions. The first and second conditions (Case 1 and Case 2) were when the sand ripple pattern was vertically and horizontally aligned respectively. The third condition (Case 3) was when sand ripples pattern was diagonal. The fourth condition (Case 4) was when there were other unnecessary objects such as fishing nets, rocks etc. in the images. These may affect the result from this image processing. **Table-1** shows the summary of this comparison. Based on this comparison, combination of Sobel X and Sobel Y filters was chosen as the most suitable filter to make choropleth map of sand ripples.

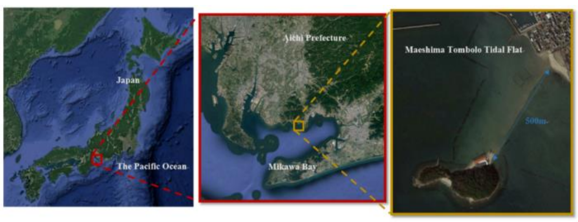

Figure-1　Location of study area

3. Result and Discussion

To find out the correlation between sand ripple formation and topography conditions in the tidal flat area, the choropleth maps of both years were compared (**Figure-3** and **Figure-4**). This comparison shows that the increase in sand ripples formation area mostly occurred at the eastern part of the tidal flat as shown in **Figure-4**. In this study, elevation variance was used as a parameter to analyze ground surface roughness. Thus, the elevation variance profiles were constructed at 3 different regions as shown in **Figure-5**, **Figure-6**, and **Figure-7**. For each region, the mean elevation was

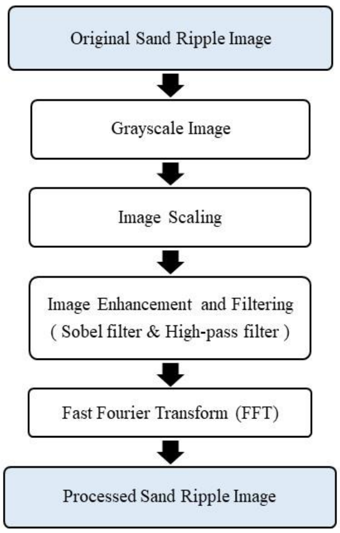

Figure-2　Flow Diagram of Image Processing

Table-1　Comparison of the filters

	Sobel X	Sobel Y	Sobel X + Sobel Y	High-pass
Case 1	○	×	○	○
Case 2	×	○	○	○
Case 3	○	○	△	○
Case 4	○	×	○	×

determined based on elevation data in both latitude and longitude directions with 0.00005°, which is approximately 5 m^2. In the latitude direction, the data at 34.78290° for region 1, 34.78350° for region 2 and 34.78390° for region 3 are extracted. The *x*-axis is the longitudinal distance [degree] and the *y*-axis is the elevation variance [m^2]. The highlighted areas are the areas where the sand ripple formation increased or was newly confirmed in 2021. In these figures, the elevation variance in the highlighted areas showed that the elevation variances significantly decreased in 2021 compared to 2020. A low elevation variance indicates that the area has a spatially smooth ground surface. For example, sand ripples were formed in both years from the longitude 137.1462° to 137.1468° in **Figure-6** and from 137.1463° to 137.1477° in **Figure-7** where the difference in elevation variance was almost constant. On the other hand, the elevation increased from 137.1479° to 137.1482° in **Figure-6** and from 137.1477° to 137.1480° in **Figure-7** where there was no formation of sand ripples in both years. While in **Figure-5**, the elevation dropped rapidly in the highlighted area from the longitude 137.1478° to 137.1480° and became almost constant afterward from 137.1480° to 137.1484° with the elevation variance in 2020 still slightly higher than 2021. Thus, it can be concluded that sand ripples will appear in the area with high decrease in elevation variance and remain unchanged when the difference in elevation variance is almost zero.

4. Conclusions

In this study, a choropleth map that showed sand ripple direction and its distribution on the tidal flat was constructed to identify the changes in sand ripple formation area and its relation to topography conditions. From the soil surface roughness analysis using elevation variance, it was found that the soil surface with low variance in 2021 was smoothed, which allowed the sand ripple to form easily. This may be due to physical weathering or erosion which moves the gravel and sand from one place to another place (sediment transport) by wind, wave, or any other natural cause. However, further study will be needed to reveal this general finding.

References

1) Murray, N. J., Clemens, R. S., Phinn, S. R., Possingham, H. P., Fuller, R. A. Tracking the rapid loss of tidal wetlands in the Yellow Sea. Frontiers in Ecology and the Environment. 2014; 12:267-272.

2) Kato, S., Kuritani, I., Nakamura, R., Okabe,T., Topographic change and sediment transport on Maeshima Tombolo tidal flat. The 2nd Aceh International Symposium on Civil Engineering (AISCE), 2020, 1-4.

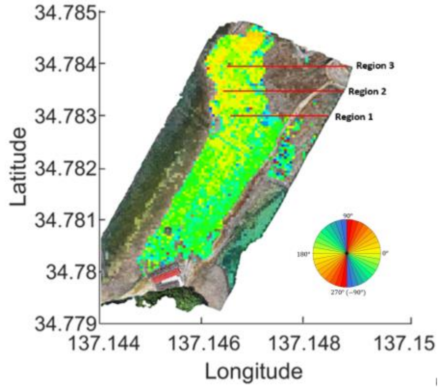

Figure-3 Choropleth map in 2020

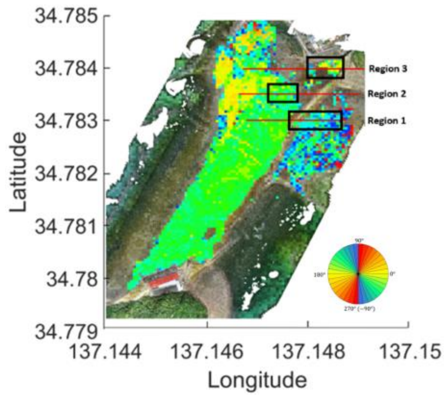

Figure-4 Choropleth map in 2021

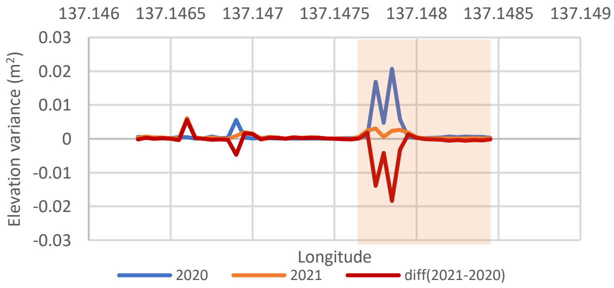

Figure-5 Elevation variance in region 1

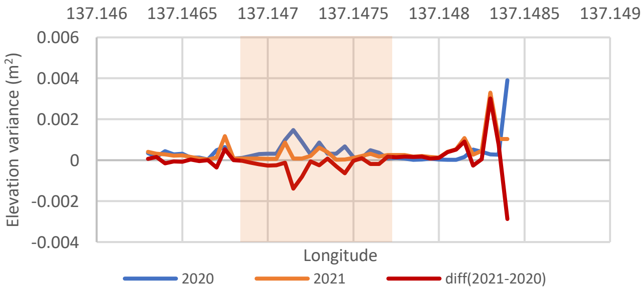

Figure-6 Elevation variance in region 2

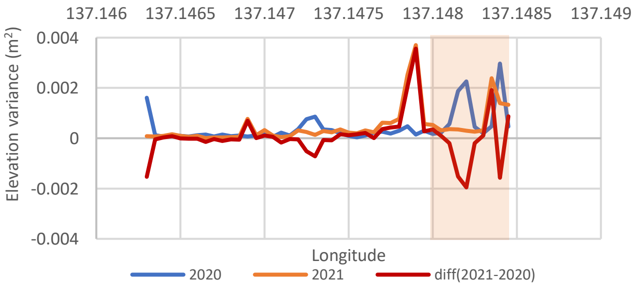

Figure-7 Elevation variance in region 3