Sampling in Geographical Fieldwork Using GIS Techniques

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Abstract

Sampling is a fundamental and essential component in geographical fieldwork. Sampling is the process of gathering data from purposefully selected sites, such that the data collected best represents the general phenomenon being studied. In geography education, teachers often have to look for suitable sites for students to conduct fieldwork, for example, which location to conduct interviews. However, many teachers are afraid to venture out into unchartered territories where the potential site for fieldwork is unfamiliar. This paper seeks to illustatre the use of GIS techniques to determine the suitability of an unfamiliar site for sampling in geographical fieldwork through coastal research done on a coastline along Cha-am, Thailand.

Unfamiliar territories

The research conducted was about the impact of coastal erosion on Cha-am's beach and Cha-am south beach and the shops along the coast. The research was conceptualised in Singapore, hence making it a challenge to visit the research site beforehand. In addition, there was no prior secondary research about coastal erosion and coastal retreat along Cha-am's coastline. To overcome this challenge, GoogleEarth and GIS remote sensing techniques were utilitised to determine the suitability of various sites for research on coastal erosion.

Utilising GoogleEarth Satellite Imagery

Firstly, GoogleEarth was used to get an overview of possible sites along Cha-am's coastline. Through GoogleEarth, the coastline was analysed using satellite images from various time scales through the time slider feature in GoogleEarth. The satellite images revealed that there was indeed coastal retreat along Cha-am coast over the years. Hence, by comparing the coastline in the different time scales, two sites along Cha-am's coastline were identified - one at Cha-am beach as a 'low erosion site' and the other at Cha-am south beach as a 'high erosion site' (Figure 1).

The 'low erosion site' was identified for having the least significant coastal retreat compared to the rest of the coastline. In addition, the 'low erosion site' had the largest stretch of beach, which is a key coastal depositional landform (Figures 2a, 2b and 2c).

Figure 1: Sites identified along Cha-am coastline (zoomed out)

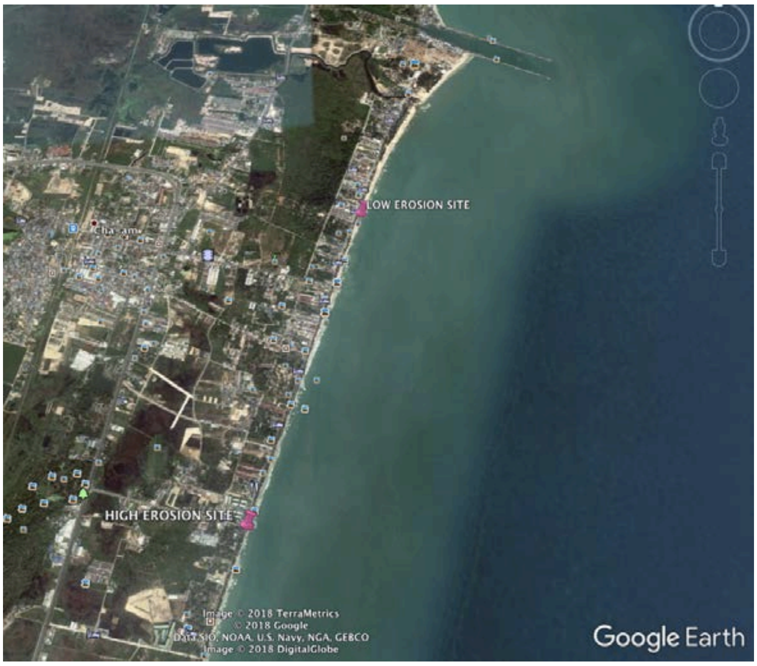


Figure 2a: GoogleEarth satellite image of low erosion site along Cha-am's coastline taken on 4th July 2005.

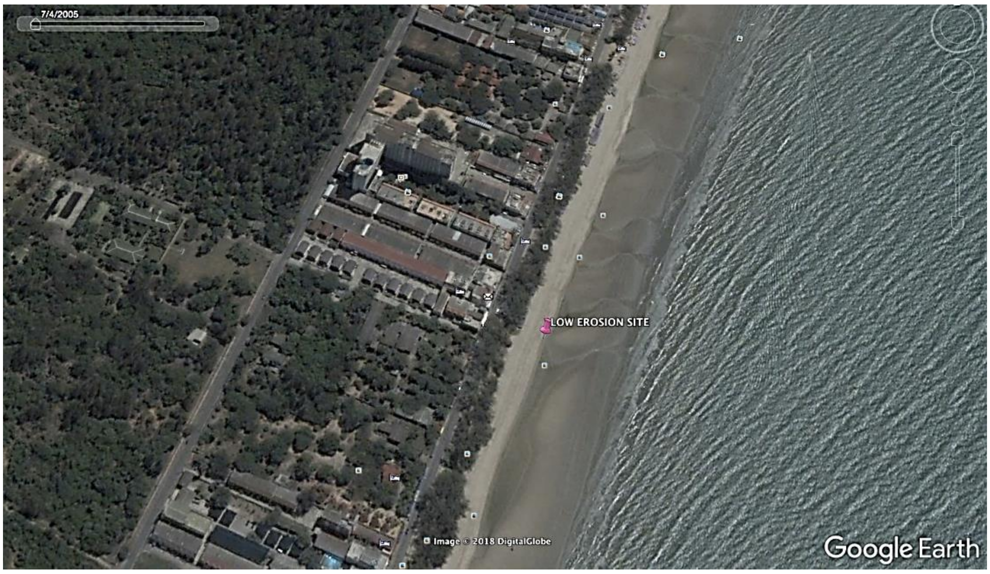


Figure 2b: GoogleEarth satellite image of low erosion site along Cha-am's coastline taken on 9th March 2014.

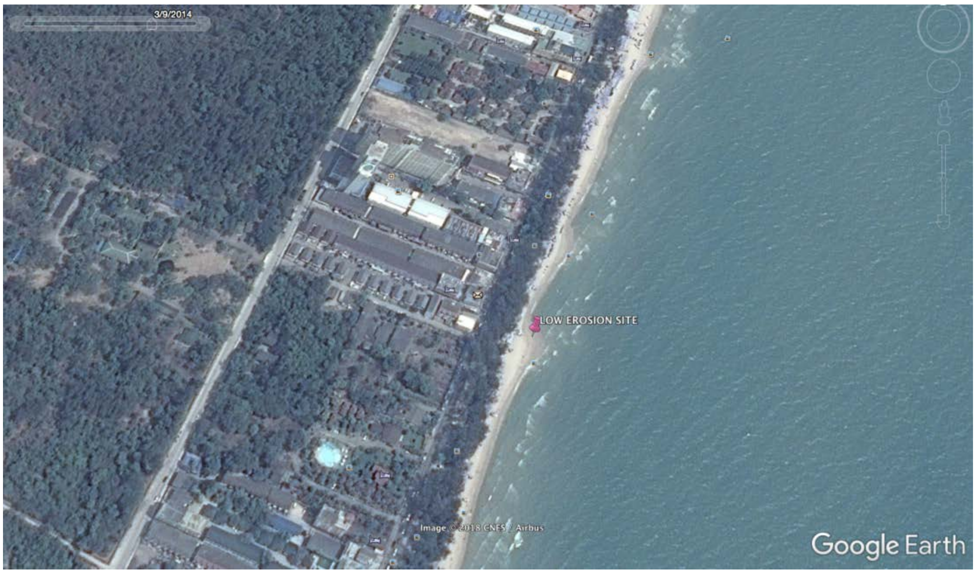


Figure 2c: GoogleEarth satellite image of low erosion site along Cha-am's coastline taken on 24th Jan 2017.

The 'high erosion site' was identified for having the most significant coastal retreat compared to the rest of the coastline. In addition, the 'high erosion site' had the narrowest stretch of beach, which highlighted that coastal erosion had taken place at that area (Figures 3a, 3b and 3c). The 'high erosion sites' were located along Cha-am south beach.

Figure 3a: GoogleEarth satellite image of high erosion site along Cha-am's coastline taken on 4th July 2005.

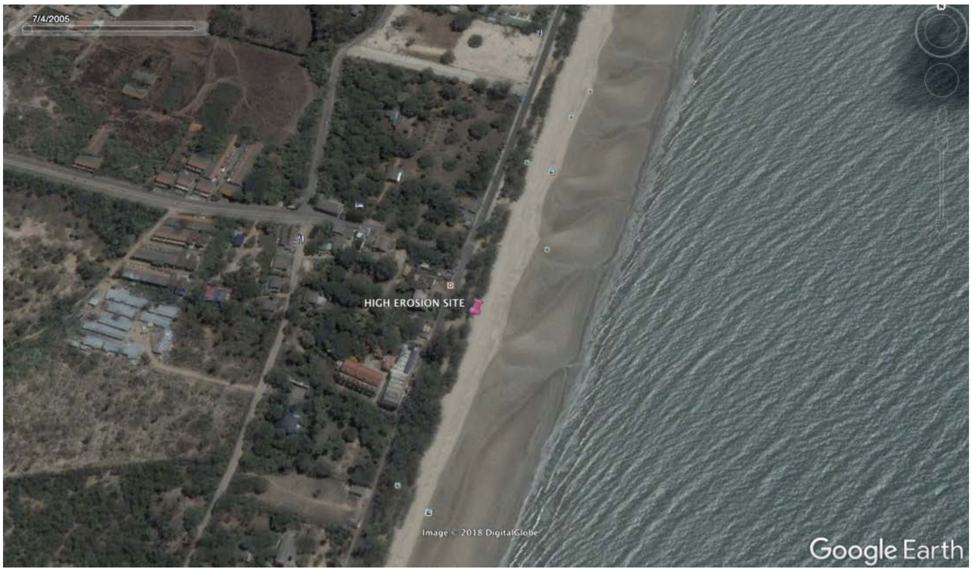


Figure 3b: GoogleEarth satellite image of high erosion site along Cha-am's coastline taken on 9th March 2014.

Figure 3c: GoogleEarth satellite image of high erosion site along Cha-am's coastline taken on 24th Jan 2017.

Utilising Remote Sensing-GIS Satellite Imagery

To further confirm the suitability of the two locations as data collection sites, Remote Sensing and Geographic Information System (GIS) technologies were employed. Remote sensing involves the sensing of a place or object remotely, to acquire information about the place or object (Ramachandran, n.d.). Remote sensing technique often uses satellites to help to collect and record information of the specific place with the help of electromagnetic radiation reflected off the Earth's surface. This information is then processed into an image after being transmitted to a receiving station (USGS, n.d.). Such images could help to track the changes in a specific place over time. Remote sensing images can be used to track changes over a targeted area for various reasons, for example, glacial retreat and deforestation in the forest.

Remote sensing technology can be used hand-in-hand with GIS. GIS is a smart mapping technology that stores and maps geographical elements to reveal patterns. GIS is particularly useful to the study of spatial relationships. When data is entered and stored into the GIS system, the system is able to generate GIS maps depending on which data layers are included. GIS maps are useful to analyse information about numbers and density, and even which areas are more prone to flooding than others (National Geographic Society, n.d.). The investigation made use of GIS remote sensing techniques to extract data for coastal erosion along Cha-am's coastline. This helped to determine the extent of coastal inundation and monitored the beach erosion along Cha -am's coast.

Landsat satellites were used in this study to generate high-resolution satellite images of the coastline of Cha-am. Landsat satellites have polar orbits; hence they are able to capture information for most parts of the Earth along with the Earth's rotation. Landsat satellites were first developed in 1972, and the first Landsat satellite was named, Landsat 1. Subsequently, Landsat 2, Landsat 3 and Landsat 4 were launched in 1975, 1978 and 1982 respectively. Landsat 5 was launched in 1984 and deactivated in 2013. It is said to be the "longest-operating Earth observation satellite", producing high quality data for many years. Landsat 6 failed to orbit when launched in 1993. Landsat 7 and Landsat 8, launched in 1999 and 2013 respectively, are currently still in operation to provide daily global data.

In Callaghan et al.'s (2015) investigation of coastal erosion along False Bay, South Africa, remote sensing techniques with Landsat TM/ETM+ imagery were used to monitor and detect coastal erosion, susceptibility to coastal erosion, and vegetation change along the bay. The remote sensing technology allowed for repetitive data acquisition, which was essential for monitoring changes in land cover over time. Another paper by Mitra and Basu (2016) also utilized Landsat imageries to assess coastal erosion and accretion on the dynamic coastal belt of West Bengal from Talshari to Rasulpur.

The scope of this study using remote sensing techniques was to be from years 2008 to 2016. However, due to the insufficient satellite images captured for each year, the high cloud cover and low resolution for some images, data was collected in a four-year interval, for years 2008, 2012 and 2016. Therefore, for the given time frame of the study, Landsat 7 (images from 1999 onwards) was utilised.

For each satellite image at each time period, the different bands for each image were merged using Erdas Imagine (2011) software. When the bands had been merged, the final image showed the extent of beach erosion of Cha-am's coastline for that time period. ArcMap was used to overlay the images of different bands to produce a single image for each time frame. Using ArcCatalog, the coastline of Cha-am from images of different time periods (i.e. 2008, 2012, 2016) were digitized so as to create an outline of the coastline for each of the time periods. The coastlines for each of the time period were then overlain into a single image, with a remote sensing image of the area as the background. The coastlines were then compared to determine the extent of beach erosion and beach retreat (Yoshida, et al., 2013). Special focus was given to the coastlines of Cha-am beach and Cha-am south beach.

Figure 4 shows the Cha-am coastline obtained from the remote sensing images in the three years – 2008, 2012 and 2016, while Figure 5 shows a zoomed in image of the same area.

From the remote sensing image results in Figure 5, at Cha-am beach ('low erosion sites'), the remote sensing imagery results show that there is no significant, observable coastline retreat from the years 2008 to 2016. The three lines (representing Cha-am coastlines in the three years – 2008, 2012 and 2016) are very much overlapping one another, which indicates that there is no significant coastline retreat or advancement recorded at that area. On the other hand, from Figure 5, at Cha-am south beach ('high erosion sites'), the remote sensing imagery reveals that there were changes in the coastline along Cha-am south beach from 2008 to 2016. The results show that certain sections along Cha-am south beach experienced coastline retreat from 2008 to 2012 and then to 2016. Results also indicate that other sections further south of Cha-am south beach showed an advancement of coastline from 2008 to 2012, followed by a subsequent retreat of coastline from 2012 to 2016, The coastline in 2016 exhibited the most extreme retreat.

Figure 4: Remote sensing image of Cha-am's coastline, where 'low erosion sites' refer to Cha-am beach and 'high erosion sites' refer to Cha-am south beach

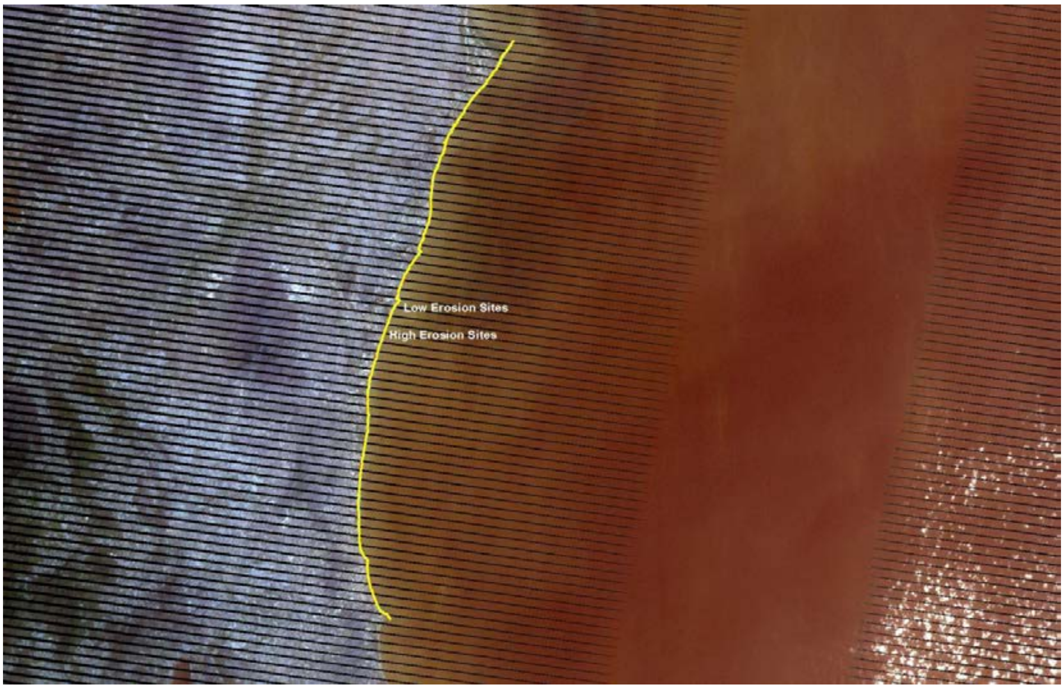
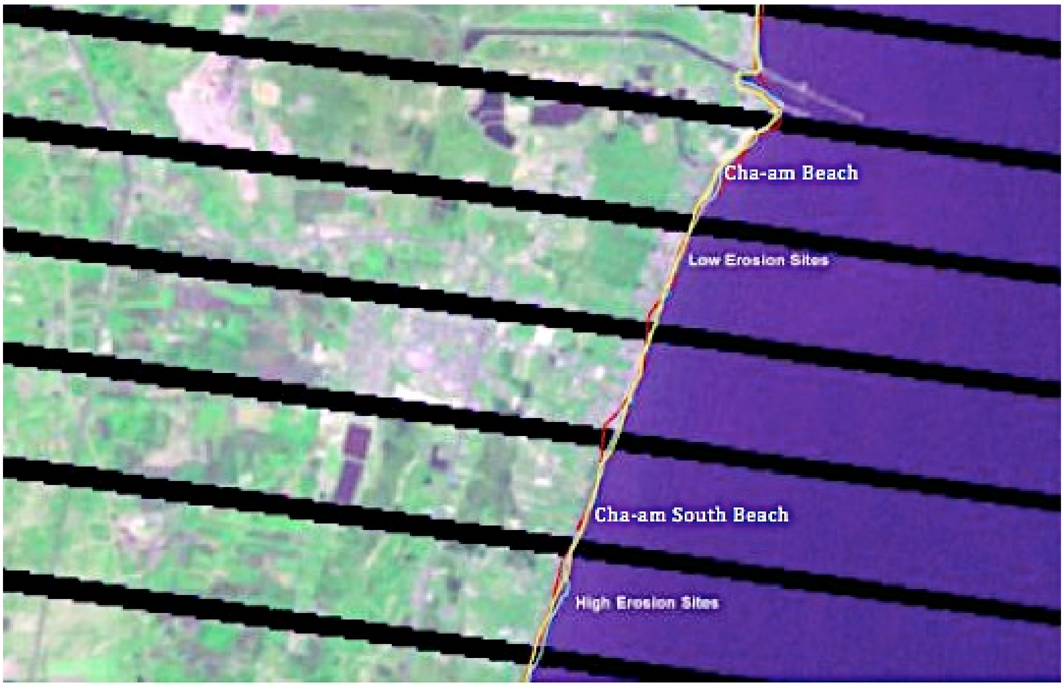


Figure 5: Remote sensing of Cha-am's coastline (zoomed in)



Legend:
Yellow line: 2008's coastline
Blue line: 2012's coastline
Red line: 2016's coastline

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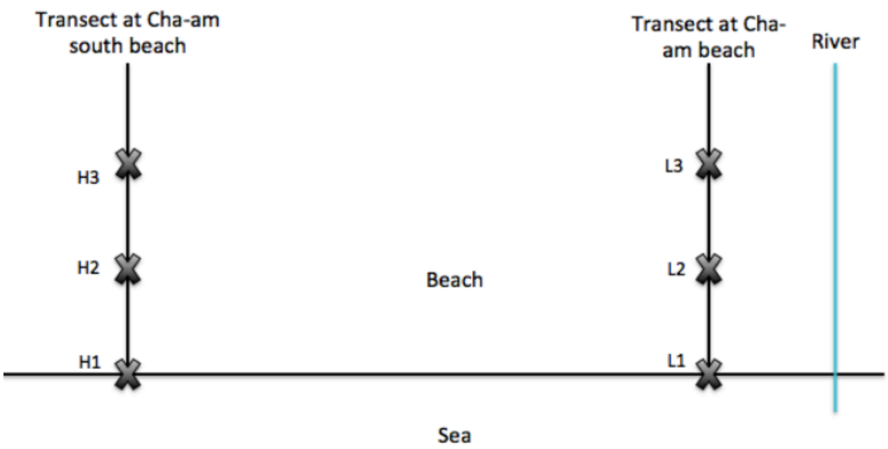
Interviews, Beach Profiling and Sediment Analysis On-Site

Due to the GIS remote sensing techniques, it was therefore possible to identify in advance, the sites for data collection. The on-site data collection included beach profiling, sediment analysis and semi-structured interviews with the locals living along Cha-am's coastline at the two selected sites of high and low erosion.

Two transects were marked out, one located at Cha-am beach and the other located at Cha-am south beach. Along each transect, three sand samples were collected at L1, L2, L3 and H1, H2, H3, at 0 m, 4 m and 8 m from the high water mark respectively (Figure 7). The collected sand samples were then sieved and analysed. In addition, beach profiling was done at the same two transects.

Figure 7: Plan view for the collection of sand samples and beach profiling along the two transects



The sediment analysis results from Table 1 reveal that the sediments collected from the transect at Cha-am south beach generally comprised of coarser and larger sediments, while the sediments collected from the transect at Cha-am beach comprised of finer and smaller sediments. Using the sediment size analysis data along with the remote sensing data (Figure 5) that shows coastline retreat indicates that the areas with highest coastline retreat and erosion (i.e. Cha-am south beach) was found to have coarser and larger sediments, while the areas with no significant coastline retreat and erosion (i.e. Cha-am beach) was found to have finer and smaller sediments. This suggests that the more erosive beaches (i.e. Cha-am south beach) generally comprised of coarser and larger sediments, which could be associated with the increased intensity of the selective winnowing of the finest fractions of sediments and the progressive coarsening of the resulting lag deposit (Guillen and Jimenez, 1995). In contrast, the less erosive beaches generally comprised of finer and smaller sediments, since the waves do not have as much energy to transport the larger and coarser materials up onto the shore.

Table 1: Composition of sediment samples using Gradistat

Transect at Cha-am beach						
Points along transect	Percentage (%)					
	Very Fine Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand
L1	0.3	2.1	53.4	43.7	0.4	0.1
L2	0.5	2.5	25.3	67.0	4.6	0.1
L3	0.1	0.1	5.7	81.0	13.1	0.1
Transect at Cha-am South beach						
Points along transect	Percentage (%)					
	Very Fine Gravel	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand
H1	5.8	21.5	59.3	12.9	0.4	0.1
H2	0	0.2	30.7	68.3	0.7	0.1
H3	0.6	3.4	22.7	70.1	3.0	0.2

The results of the beach profiling at the two transects show the stark differences in beach gradients between Cha-am beach and Cha-am south beach. The beach profile of Cha-am beach (Figure 9), rose in gradient gradually. However, for the beach profile of Cha-am south beach (Figure 10), the beach was relatively flat near the sea. This is due to the strong backwash, characteristic of an erosive beach, where strong waves wash the sand quickly away from the beach back into the sea. However, the beach gradient along Cha-am south beach transect rose abruptly. This is due to the presence of big rocks and sand bags that were piled up as hard engineering measures by the locals and the government, to protect the coast from further retreat (Figure 11).

Figure 9: Profile of transect at Cha-am beach

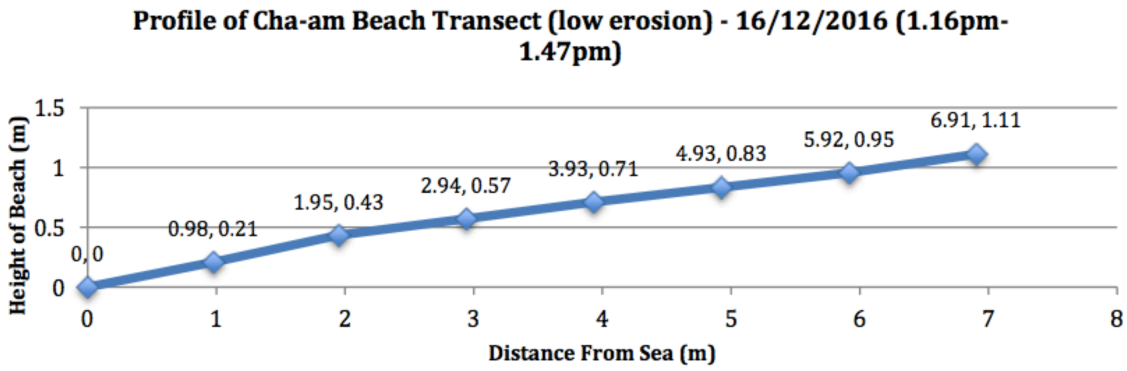


Figure 10: Profile of transect at Cha-am south beach

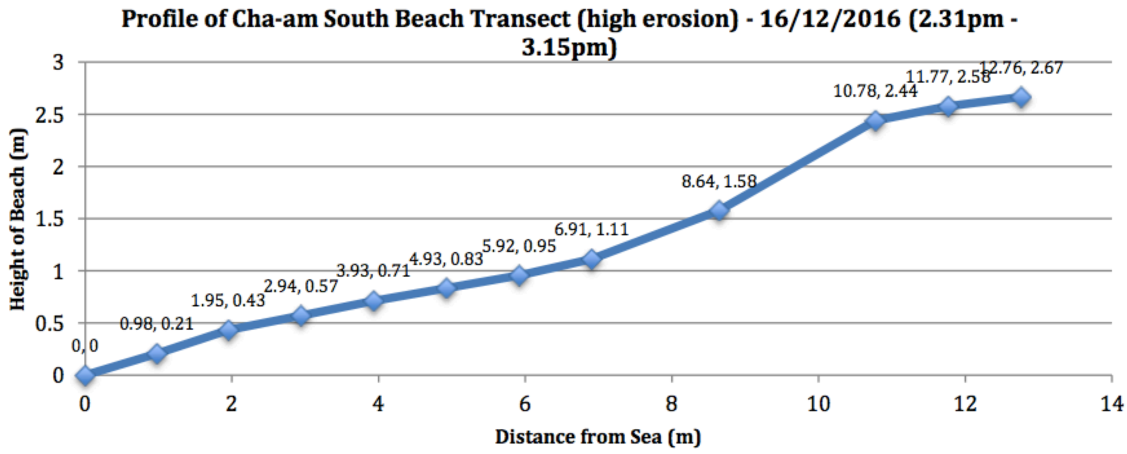


Figure 11: Abrupt change in beach gradient due to big rocks and sand bags

Finally, interviews were conducted with the potential stakeholders who are at the frontline of coastal erosion along Cha-am's coastline, and to compare the experiences of shop owners at Cha-am beach with Cha-am south beach. Through the interviews, it was further confirmed that the impacts of coastal erosion were not very prevalent and significant at Cha-am beach. Many respondents said that they had no problems with their shops situated so near the sea. On the other hand, interviews at Cha-am south beach showed that the impacts of coastal erosion, such as coastal flooding, were strongly felt. Many of those interviewed expressed how such high sea levels and intense storm events were not present in the past and had been increasing in recent times. Additionally, some respondents noted the retreat in coastline over the years, resulting in a much shorter beach at Cha-am south as compared to the past, which had affected their tourist numbers.

Implications of Research

The analysis revealed that the research results on-site (i.e. the interviews, sediment analysis and beach profiling) were consistent with the data gathered off-site using GoogleEarth and GIS remote sensing satellite imagery. This suggests that the method of sampling an unfamiliar site using GIS remote sensing technology is useful and potentially accurate.

Geography teachers are constantly required to make decisions on the locations for sampling in fieldwork with key geographical concepts in mind – space, place, scale, interdependence, environment, physical and human processes. However, there may be many uncertainties in the fieldsite or sampling location. Due to certain constraints, the teacher may not be able to explore the fieldsite before embarking on the fieldwork with students. Technology can therefore be used to assist in making these decisions. For example, the teacher could utilise GoogleEarth and other relevant satellite images for students to do a pre-fieldwork analysis of the fieldsite. Furthermore, GIS remote sensing technologies are able to go beyond the present and what appears at face value, to examine the historical data of the study area and how it has evolved over time. Although such data can be backed up and gathered through anecdotal accounts from interviews with the relevant stakeholders, the data collected from GIS remote sensing technologies serves as a good starting point for the selection of a suitable fieldsite for the geographical investigation.

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