DEVELOPMENT OF 3D BIM FOR COASTAL ZONE MANAGEMENT

Watchara KESDECH, Siriluk PRUKPITIKUL and Prapaporn PACHEERAT

Geo-Informatics Scientist, Geo-Informatics development center,
Geo-Informatics and Space Technology Development Agency (Public organization),

120 (Building B) Chaeng Wattana Road, Laksi District, Bangkok 10210, Thailand;
Tel: +66(0) -2141-4533; Fax. +66(0) -2143-9605
E-mail: watchara@gistda.or.th, siriluk@gistda.or.th, papaporn.bb@gmail.com

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Abstract

Thailand's coastal zone covers twenty-three provinces considered as important economic areas abundant in natural resources. At present, Thailand's coastal areas have undergone changes as a result of human actions, climatic change, violent winds and inappropriate use of land, thereby causing erosion and accretion in coastal zones. This study concerns with development of 3D models using the BIM technique (Building Information Model) to create models of important structures having physical impacts on coastal areas, such as wharves, breakwaters and buildings, etc. In addition, in this study geo-informatics programs were implemented to analyze coastlines, calculate areas of erosion and accretion, including the predicted changes in the studied coastal areas. In summary, the development of 3D models will enable transmission of virtual physical coastal characteristics while helping to analyze impacts and changes in coastal zones with greater accuracy and efficiency.

1. INTRODUCTION

Thailand's coastal zone covers twenty-three provinces with a total length of approximately 2,614 kilometers divided into a stretch of 1,660 kilometers along the Gulf of Thailand with seventeen provinces and another stretch of 954 kilometers along the Andaman Sea covering the coastal zones of six provinces (Cherdvong Saengsupavanichet al., 2009). Thailand's current land use of coastal areas has changed from conditions in the past due to human actions, climatic change, violent winds and inappropriate use of land, thereby causing coastal zones to undergo erosion and accretion. According to the study conducted in 2010 by Geo-Informatics and Space Technology Development Agency (Public Organization), Ministry of Science and Technology, Thailand's coastal erosion situation by analyzing Phase 1 satellite images (2010) showed the changes in coastal zones in 1999-2009 to cover an area of 22,827 rai due to damages from coastal erosion and an area of 19,527 rai resulting from accretion. From the aforementioned area changes, studies were initiated and two popular solutions for preventing and solving the problems of coastal zone changes were established. Hard solutions consist of groins, seawalls, headlands, sand sausages and breakwaters, etc. (Payom Rattanamanee and colleagues, 2008). Soft solutions consist of beach nourishment, sand dune nourishment, mangrove planting and defined setbacks, etc.

The area of Klong Wan Beach, Muang District, Prachubkirikan, is an area marked by the construction of structures to protect the coast in order to prevent further damages to the area. This study comprised the development of a 3D BIM model to build models of significant structures, such as wharves, breakwaters and buildings, etc. Furthermore, this study implemented geo-informatics programs to analyze the coastline and calculate areas of erosion and accretion with prediction of coastal changes and the presentation of 3D maps of the study area in Klong Wan, Muang District, Prachubkirikan.

2. OBJECTIVES

2.1. To create a 3D BIM (Building Information Model) of Klong Wan, Klong Wan, Prachuabkirikan.

2.2. To implement geo-informatics technology in analyzing, calculating and presenting the 3D maps of Klong Wan, Klong Wan, Prachuabkirikan.

3. STUDY AREA

The coastal zone of Klong Wan Beach, Muang District, Prachuabkirikan covering the area in the figure 1 was chosen as study area.

Figure 1: WorldView-2 Satellite Image of Klong Wan**,** 29 December 2009

4. RESEARCH DATA AND INSTRUMENTATION

4.1 Data

Table 1: Details of Data

Data	Description of Data	Source
1. Geographical map.	Map Scale: 1:50,000 from Royal Thai Survey Department; repeat of Set No. L7018 in May No. 4932 III	Royal Thai Survey Department.
2. Model of geographical height.	Digital data file.	Geographical map.
3. Data concerning the sites of structures (such as wharves,	Point Vector data in Point form.	Field survey.

Table 1: Details of Data		
Data	Description of Data	Source
breakwaters and important sites, etc.).		
4. Details of structures such as wharves, breakwaters and important sights, etc.).	Photographs, images.	Field survey.
5. WorldView-2 satellite image data recorded 29 December 2009.	Raster files data.	Geo-Informatics and Space Technology Development Agency (Public Organization)

4.2 Work Materials and Equipment

1) Cameras.
2) Global Positioning System (GPS) devices.
3) Computers.
4) The 3D BIM (Building Information Model) program.
5) Programs for designing 3D maps.

5. RESEARCH METHODOLOGY AND PROCEDURES

The study to develop 3D BIM to manage coastal zones and implement with geo-informatics technology employed the methodology shown in Figure 2 as follows:

5.1 Data collection, preparation of databases and entry to the area data and data on characteristics such as geographical maps, geographic height models, data related to the locations of structures, satellite images, coastline data, coastal erosion and accretion data, etc. Since this study collected data from multiple sources and because data was obtained from surveys, some of the data had mismatch in geographical coordinates. Therefore, before conducting the study, the data had to be managed and modified within the same geo-informatics database by citing the UTM co-ordinate system in Zone 47, North.

5.2 Survey field data, data collection on the coordinates of important buildings and structures together with data collection on the details, characteristics, shapes and structures of buildings and structures, such as wharves, breakwaters and important places, etc.

5.3 Design 3D BIM (Building Information Model) of various structures such as wharves, breakwaters and important places, etc., by using the Google Sketch Up program.

5.4 Categorization of coastlines by analyzing satellite images of 2003-2010 which displayed spectral images recording the reflectance values of the electromagnetic waves in nearby infrared wave intervals (Single band) capable of categorizing beach and seawater areas by object based classification data. The data was then exported in the form of Polyline data. Predictions related to the coastlines were made with a mathematical model.

5.5 Data for areas with erosion and accretion were acquired from the analysis and evaluation of Thailand's coastal erosion situation by using satellite images (Phase 1) of 2010 of the Geo-Informatics Center, Department of Geo-informatics Application Processing Development, Geo-Informatics and Space Technology

Development Agency (Public Organization) to calculate for areas with erosion and accretion by a geo-informatics program from coastline data with object-based categorization into Polyline data and convert into Polygon data. Next, the areas with erosion and accretion would be distinguished from one another by using the following equations:

Areas of Erosion = A – (A Intersect B)

Areas of Accretion = [(A Union B) – (A Intersect B)] – A

Where A = Coastal zone before impacts from waves.

B = Coastal zone after impacts from waves.

5.6 Implementation of geo-informatics technology by using the ArcGIS program to design 3D maps showing the characteristics of coastline changes, area erosion and accretion.

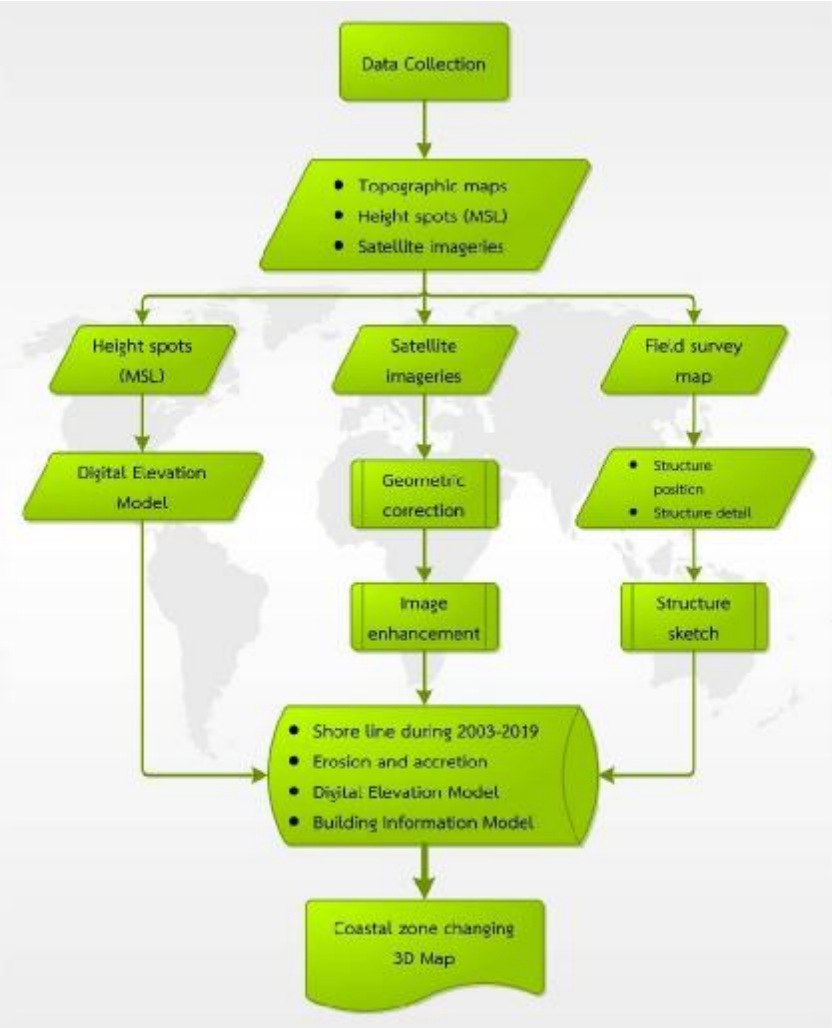


Figure 2 - Chart of Research Methodology and Procedures

6. RESULTS

6.1 Preliminary data on Klong Wan area collected from various sources were used to prepare a database for designing the models. The preliminary data which was prepared comprised the following:

6.1.1 The Digital Elevation Model.

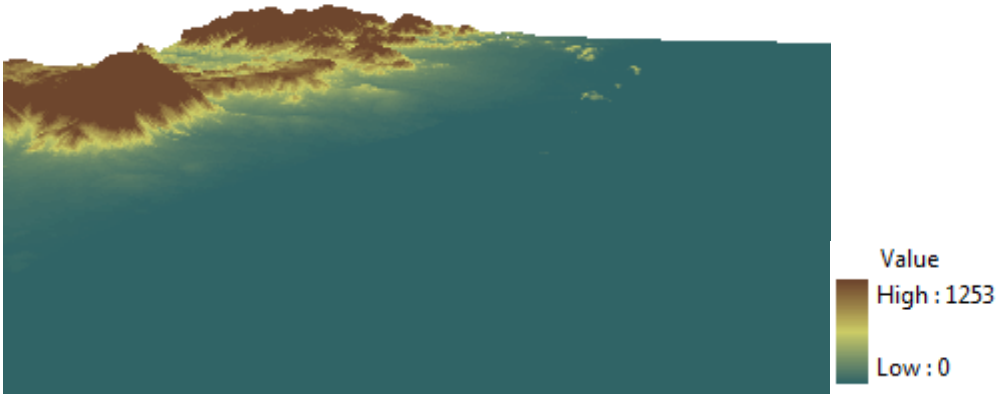


Figure 3: Geographical Characteristics

6.1.2 Satellite Image Data.

Development of 3D BIM to manage coastal areas using satellite images in analyzing coastlines and accompanying 3D BIM as follows:

1) IKONOS satellite images of Klong Wan, Prachuabkirikan, acquired in 2003 and 2004 with image details at one meter for coastline analysis.
2) SPOT5 satellite images of Klong Wan, Prachuabkirikan, acquired in 2007 with image details at ten meter for coastline analysis.
3) SPOT5 satellite images of Klong Wan, Prachuabkirikan, acquired in 2009 and 2010 with image details at fifteen meter for coastline analysis.
4) World View-2 satellite images of Klong Wan, Prachuabkirikan, acquired in 2009 with image details at 0.5 meter to accompany the 3D BIM.

6.1.3 Field surveys and data collection on coordinates and structural details were as follows in Figure 4 and Table 2.

Figure 4: Locations of Coastal Structures at Klong Wan

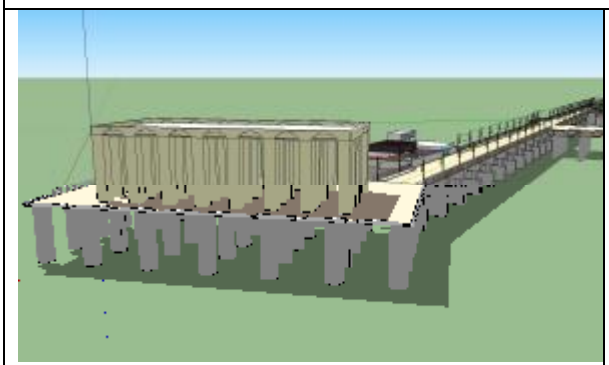
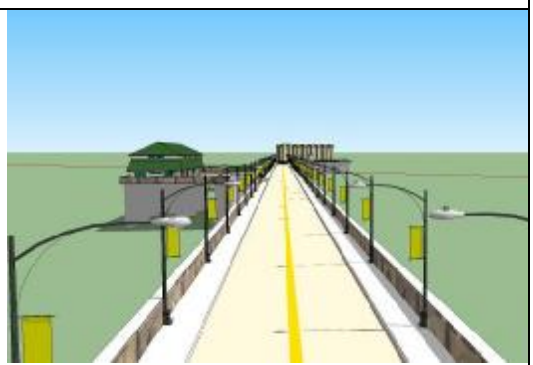
Table 2: Structural Details

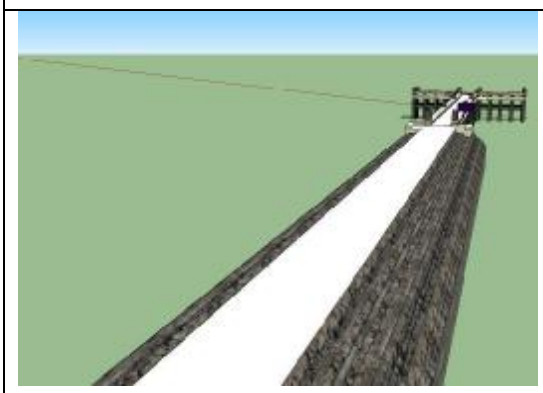
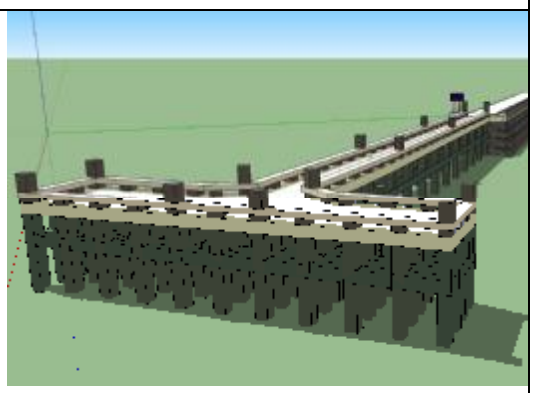
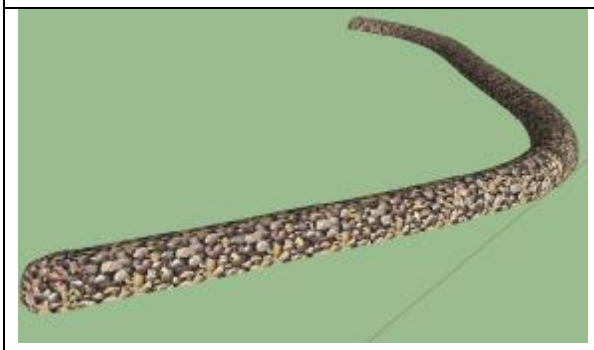
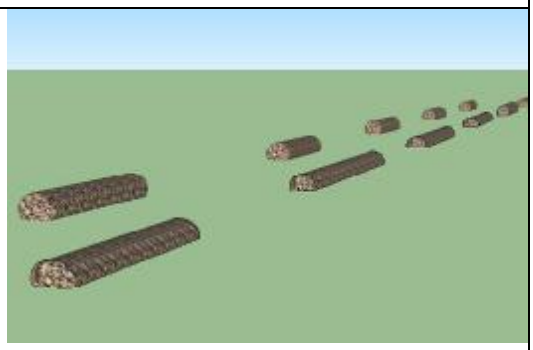
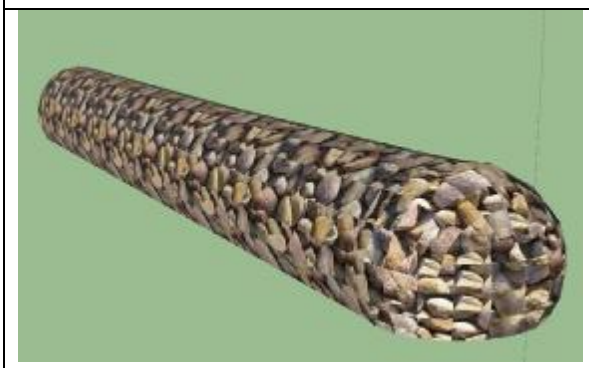
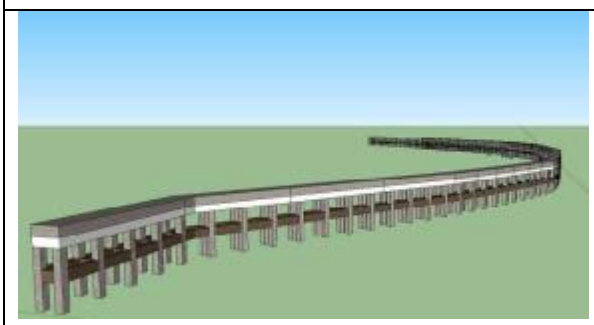
Piers 2			
Details			
Piers 1			
Details			
13 Break water			
- Large break water			
Details			

- 12 Small break water			
Details			
groins			
Details			
- Other structures			
Details			

6.2 The 3D BIM model was designed by using the Google Sketch Up program to design structures in the coastal areas at Klong Wan as follows:

Table 3: 3D Building Information Model

Piers 2	
	

Piers 1	
	
Large break water	Small break water
	
groins	Other structures
	
Other structures	Other structures
	

6.3 Analysis of Coastal Changes

This study analyzed the coastlines by implementing programs for geometric correction and image enhancement to analyze the coastlines and areas with erosion and accretion.

6.3.1 2003-2019 Coastline Analysis – Analysis by performing image classification of temporal satellite images. This step involves the process of visual interpretation of coastline data from single band satellite data, i.e. NIR (Near Infrared) by separating ground from water before predicting future coastlines by implementing the mathematical model with the analysis results shown in Figure 5 and Table 4.

Figure 5: 2003-2019 Klong Wan shore line of the Area

Table 4: shore lines by Year

Shore line in 2003	Shore line in 2004
	
Shore line in 2007	Shore line in 2009

Shore line in 2010

6.3.2 2003-2019 Erosion and Accretion – Analysis implementing geo-informatic programs to calculate areas of erosion and accretion. Coastline data categorized into Polyline data according to 6.3.1 is converted into Polygon data before separating the areas of erosion and accretion from one another by using the following equations with results from analyzing areas with erosion and accretion as shown in Figures 6 and 7, respectively.

Equation: Area with Erosion = A – (A Intersect B)

Area with Accretion = [(A Union B) – (A Intersect B)] – A

Where A = Coastal zone before impacts from waves.

B = Coastal zone after impacts from waves.

Figure 6: Erosion of the Klong Wan Area in 2003-2019

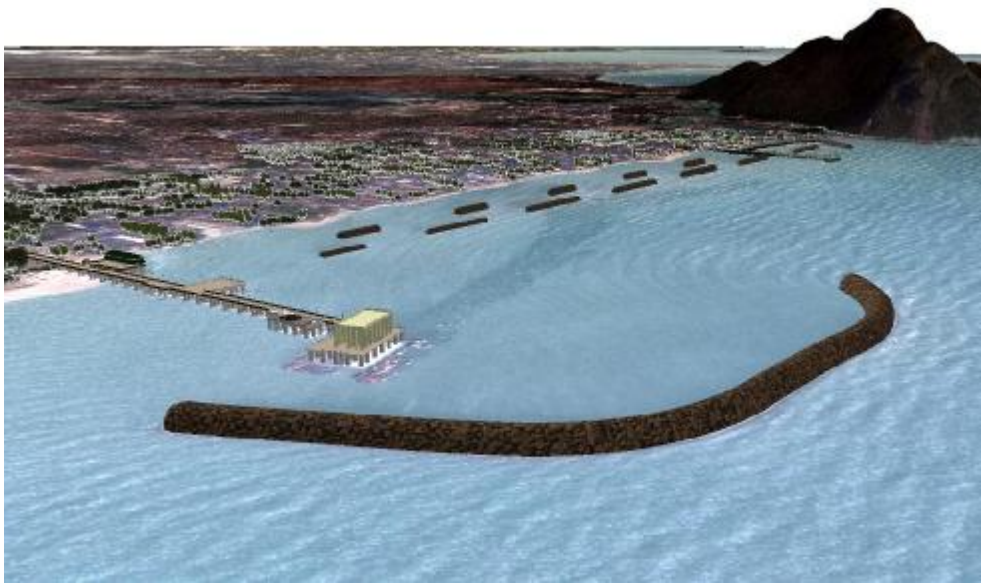
Figure 7: Accretion of the Klong Wan Area in 2003-2019

6.4 Designing a 3D Map Model

In designing 3D maps, the data acquired from collection, analysis and preparation, e.g. from the Digital Elevation Model, World-View-2 satellite images, locations of structures, 3D BIM, coastlines, erosion, accretion

and other accompanying data was used to design the 3D map model by implementing the geo-informatic programs as shown in Table 5.

Table 5: Image of 3D Map Models (In Different Viewing Angles)



7. SUMMARY AND CRITIQUE

The study to develop the 3D BIM to manage coastal zones employed BIM designing technology to design models for the structures of the Klong Wan Beach area, Muang District, Prachuabkirikan. The model designed structures such as wharves, breakwaters, buildings and other important structures in conjunction with geo-informatics technology to analyze coastlines, calculate areas with erosion and accretion for 2003-2019 and then create a 3D map model. At present, the integration of both technologies created new knowledge and understanding of the area's geographical characteristics in order to help increase the effectiveness of planning and management of coastal zones. The present study is similar to the study of Mohamed El-Mekawy (2010) who integrated BIM and GIS technologies to design 3D city models and was able to conduct comprehensive

development of areas, e.g. city planning, building structure analysis and security, etc. Peter Wheeler et al. designed a 3D map of flooding in lake coastal areas in Australia, which can be implemented to provide data for persons involved with the problem and persons responsible for management in order to plan land utilization, make designs to reduce risks and expose the awareness of stakeholders. Rolf Gabler-Mieck and Rainer Duttmann (2007) mentioned the implementation of Geovisualisation technology in coastal management, stating that 3D image creations were increasingly used in space science and planning. At present, instruments are used to create images of virtual areas by using geographical data, such as the Digital Elevation Model, aerial photography and satellite images, etc.

In developing and implementing 3D BIM technology, 3D BIM technology can be used to support management of coastal zones because the transmission of area characteristics in the form of a 3D model can help build understanding and views of the areas with greater clarity. At present, the instrument is popularly implemented with studies in other aspects.

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