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Using drone mapping to analyze risky areas and predict LULC at Sichang Island, Chonburi province, Thailand

Suwatcharapong Surasanpreedee[*1,2,3] **Kitsanai Charoenjit**[*1] **Zhenfeng Shao**[*2]

[1]Burapha University, Geoinformatics, Chonburi, Thailand
[2]Wuhan University, State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan, China
[3]Geo-Informatics and Space Technology Development Agency, SCGI: Sirindhorn Center for Geo-Informatic, Chonburi, Thailand

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Remote sensing
LULC
Risky area
CA-MAKOV model

ABSTRACT

Thailand is a country located in Southeast Asia, the Thai government wants to become the economic leader of ASEAN, so there is an economic development plan named EEC (Eastern Economic Corridor), a megaproject with a huge investment but the Thai government is focusing only on the mainland. The researchers determined that there is still an area that is more outstanding than other islands (Gulf of Thailand), Sichang Island, located in Chonburi Province, has sufficient potential for development. This research study the knowledge of Geoinformatics, remote sensing, and aerial imagery from the drone are used to conduct research, to determine the potential of the development of the Sichang Island area. These include finding risky areas on the island and predicting future LULC in the next 10 years by using aerial imagery from drones as a base. The results were obtained, there is a village in the community in highly risky area (flood and land-slides combined) 2.865 % of Sichang area, and the prediction of the future LULC is the continuous expansion of urban-build up area 9.348%.

1. INTRODUCTION

The Thai government established a mega project called the Eastern Economic Corridor (EEC) with 3 model provinces, Chachoengsao. Chon Buri and Rayong provinces, with only focus on the mainland but still has an important island called “Sichang” in the area of Chonburi Province and is also a district in Chonburi Province as well. These island that is unique in culture, tradition and tourism. Therefore, in response to the government's policy of driving the economy in this region, it is appropriate to prepare the information of digital geographic information system of Sichang Island but the spatial area study is small-scale (only around 6.5 square kilometers). If using satellite images (free data) such as Landsat or Sentinel, the resolution is not enough. If we use very high-resolution satellite imagery, then there will be many budgets of buying satellite imagery data. For this reason, with this solution. It is advisable to use an unmanned aerial vehicle (UAV) or drone to capture aerial imagery because the drone has the advantage such as it helps to save budget and time. Drone is currently able to capture images. We can choose the time period to flying. Current drone price not expensive and getting cheaper according to the advancement of technology. Nowadays drone is becoming more popular equipment in geo-informatics system.

Research objectives:

1. Assessing the location of natural disaster risk areas (complex, landslides, floods) in Sichang Island, Chon Buri province, Thailand

2. Predict LULC for next 10 years in Sichang Island, Chon Buri province, Thailand

In this study, Map of Sichang Island, which is located in the coordinates 13 ° 38 ′ 59″ N - 100 ° 48 ′30 E, was produced. Given in Fig 1.

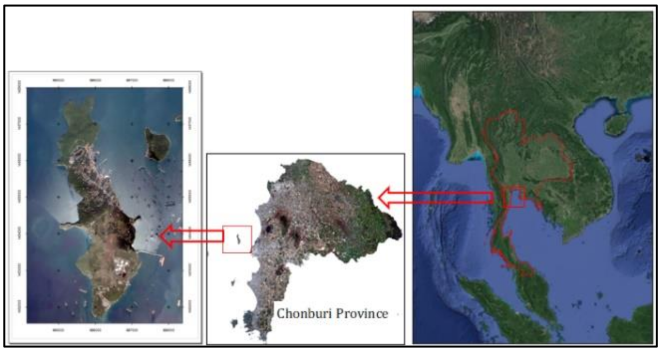

Figure 1. Location Map

2. METHOD

This thesis has 5 conceptual frameworks which are (1) area study (2) data collection (3) data processing (4)

* **Corresponding Author**

*(62910174@go.buu.ac.th) ORCID ID 0000 – 0003 – 0689 – 2284
(kitsanai@go.buu.ac.th) ORCID ID 0000 – 0003 – 4290 – 6778
(shaozhenfeng@whu.edu.cn) ORCID ID 0000 – 0003 – 4587 – 6826

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data analysis and (5) conclusion. The most difficult step is step (2). After we choose the area study, Sichang Island. The data collection on Sichang is done by UAV or drones. Flying for capture many images, taking full 1 day for total area of the island, different from other thesis, that use satellite imagery which is much easier, just download the information from some website in a short time. But this method takes the advantage in steps 3 and 4, are easier than other methods because the images from drone have very height resolution, allowing for easier processing and analysis and are more accurate result. There are two processes in step 4, the process of finding risky areas on Sichang Island and the process of predicting LULC in the next 10 years on Sichang Island.

Table 1. Data sources.

Sensor	Date	Resolution	Source
Drone	2019/09/01	7 cm.	Drone DJI Phantom4.
Ortho RGB aerial photo	1999, 2009	50 cm.	Royal Thai Survey Department
Landsat 8 OLI	2019/09/28	30 m.	https://earthexplorer.usgs.gov/

2.1. Data collection step

Drone data: The researcher used Drone DJI-Phantom 4 to capture aerial images of whole Sichang Island area, flying at altitude 200 meters from the ground. The image, with a resolution of about 7cm., flew drone on October 1, 2019, taking 1 day to collect all areas in the Island. the steps are as follows: (1) Select a drone "DJI Phantom 4" (2) Select Application DJI Go 4, made a connection between I-Pad (or smart phone) and Drone for basic control (3) For flying Drone to mapping, we use the automatic PIX-4D Mapper application to make it, set the height to 200 meters. (4) When planning to fly, must not fly against the direction of the wind, because the area is an Island in the middle of the sea, when flying high, there is a chance that strong wind, is the reason for lose battery power and reduced working time of the drone.

Ortho RGB aerial photography at Sichang Island: Data Raster (spatial resolution 50 cm, 3 Bands) Year 2009 from Royal Thai Survey Department.

Other information: are used to make decisions in the Sichang Island risk areas table (AHP)(Jin-Yu, Zhong-bin, & Qing-yun, 2008), such as include Rainfall data, slope, soil type (capacity of water flowing through the soil), distance from the reservoir, and geological data.

2.2. Data processing

Drone data: take aerial photos from the drone to mosaic via application "PIX 4D Mapper" which will get the base map for this research. This step is most important, after the drone has finished taking aerial photos, many data is stored on the SD card of the drone, moving the data to computer, and then using PIX 4D Mapper to manage (mosaic) all photos, there are 3 steps: (1) rayclouds (2) volumes (3) mosaic editor. In this step, we will get a mosaic image of Sichang Island. After that, resample the image resolution (7 centimeters) to 1 meter in order to facilitate the calculation of the computer. and clip the area by only real Sichang boundary. (obtained the shapefile boundary from the digitizing drone image)

Ortho RGB aerial photography at Sichang Island, Resample the image resolution from 50 centimeters to 1 meter (Must have the same size and number of pixels as the Drone image) because it is a requirement to calculate the area of future changes via CA-MAKOV model. Create a new shape file by digitizing, based on drone image. Identify by visually because resolution 1 meters can already be seen clearly.

Data for make decisions AHP, DEM calculations, slope calculations, distance of water sources can be found on drone data. NDVI values used data from Landsat satellite image. Other information can be found on the Thailand government agencies website such as Land Development Department, Meteorological Department. and then resample resolution to 1 meter again.

2.3. Data analysis

2.3.1. Assessing the location of natural disaster risk areas (landslides, floods)

Manipulate in Arc-GIS program**.** Calculate two types of risk value, which are flood and landslide. After getting results from both types of risk areas map, then combine them together to find complex risk areas again.

Risky areas (flood), the data used include elevation, slope, soil type (capacity of water flowing through the soil), distance from the reservoir, and geological data.

Risky areas (land slide), the data used include Rainfall data, slope, soil type (capacity of water flowing through the soil), distance from the reservoir, and geological data. Prove C.R. value < 0.1 Therefore, the consistency of comparison is within acceptable values. (Flood = 0.084, Land slide = 0.030). Take the boundary of Sichang Island (obtained from the digitize image from the drone) to clip with all data layers, so every layer is same size. Make all 7 layers of data into raster data and assign values 1,3,5 (Risk level height = 5, medium = 3, low = 1), in this step, we will see the color difference shown in each data layer. After that just reclassify to only 3 types. Layers of information are combined with Arc GIS to create risk maps area. Use the previously calculated Eigenvector as the weight for each criterion (multiply). Use the map algebra function in Arc GIS to manage risk mapping, selected spatial analysis tools >map algebra >raster calculator. After getting the risk map (land slide and flood), bring both of them to the combined risk area map. By using 1:1 weighting. Use the map algebra function in Arc GIS again. In the final step, you will get a combined risk map. The equation used to calculate the risk area:

Flood risk area = 0.131x (Elevation) + 0.205x (slope angle) +0.320 x (drainage) + 0.131x (land use) + 0.047x (Lithology) + 0.120x (distance from the reservoir) + 0.045x(NDVI)

Landslide risk area = 0.256x (Precipitation) + 0.194x (slope angle) +0.255 x (drainage) + 0.136x (land use) + 0.042x (Lithology) + 0.060x (distance from the reservoir) + 0.057x(NDVI)

Complex risk areas = 0.5x (landslide prone areas) + 0.5x (flood-prone areas)

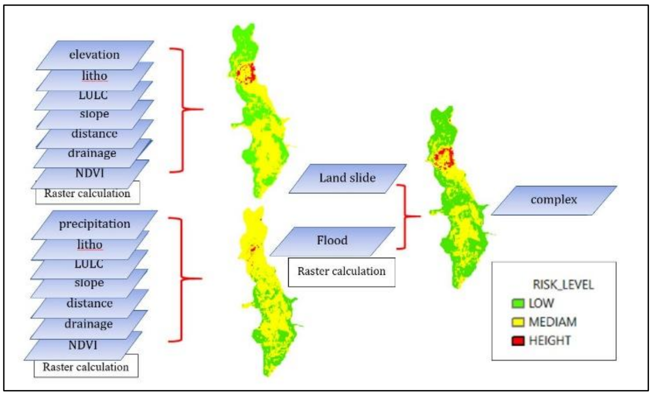

Figure 2. The process of creating risk area map, land slide, flood, complex

2.3.2. Predict land use land cover for next 10 years

High-resolution image from the drone (resemble to 1 meter) as a base to classify (by digitize) Sichang LULC area into 4 types (no agriculture area on Sichang Island) which are (1) forest area (2) miscellaneous area (3) urban and buildup (4) water body. Classify by visual identification. For my proposal the file type is img. We can exactly identify LULC types by visually because the Sichang Island map (resolution 1 meters) can already be seen very clearly. Another benefit of using very high-resolution images from the drone is the ability to know the details until the object type is well identified. Such as the width of the road or drain gutters on the side of the road etc.

Use Ortho RGB aerial photography at Sichang Island (resemble 1 meter) as a base to classify (by digitizing) the Sichang area into 4 types. Sorting types must be the same as for drone classification. The file is img. type. Identify LULC types by visually. Next Step of digitizing Sichang LULC from Drone image or Ortho RGB image. Add data (1) Sichang map layers from drone and Ortho RGB(Royal Thai Survey Department) (2) shapefile boundary from the digitizing drone image. Begin with the digitizing urban-build up area, which consists of urban areas, buildings, roads, alleys, docks etc. Digitizing water body area, which consisting of reservoir, pond etc. Digitizing forest area, which consisting of forest, brake, group of trees, shrubs etc. Union urban and buildup, water, forest area together, check every area not overlap by intersect method. Perform by geoprocessing. Do not allow any overlapping areas because this will negatively affect the conversion of polygon to raster files. Shapefile boundary from the digitizing drone image, use this shapefile erase the union area from union Forest, Urban-build up, Water body area, the output is miscellaneous area. Union forest, miscellaneous, urban and buildup, water area together. Do not allow any overlapping areas. Before converting the file to raster. Must be ordered in the attribute table strictly. The adjustment is edit feature> start editing> open attribute table> set value 1 2 3 4 for Forest miscellaneous urban water respectively. Converse polygon to raster. Last step is check that the sequence of LULC types is as needed. (1=forest, 2 = miscellaneous, 3 = urban buildup, 4 = water body)

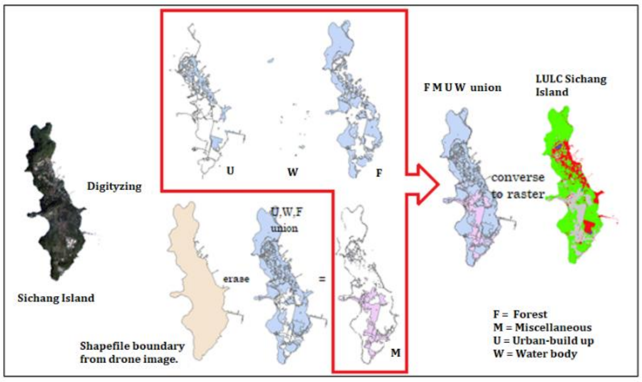

Figure 3. Sequencing process for digitizing LULC.

Make both images (Year 2009, 2019) have the same area and number of pixels, same columns and lows value, image resolution (at 1 meter) and in the same type of classification (1) Forest (2) Miscellaneous area (3) urban areas (4) Water body and must be arranged in sequence. (every file must be img.file). Export 2 file .img about LULC Sichang Island map (year 2009 2019) to new folder and set the name's folder. For the next step, we will work entirely on this folder only, set value extent raster dataset and spatial reference = size (original), cell size = 1,1 no data = 5, format = IMAGIN image (.img file)

IDRISI: MAKOV Chain step. Example predict Year 2029 (used base map on year 2009 compere year 2019) Use the IDRISI program to calculate future LULC area changes. The first step is to create a new folder, separated into working folders. Converse .img file to .rst file Import image by Geotiff/tiff (depend on ArcGIS version) or .img file. This proposal is .img file. Open new .rst file that got from the value of the previously obtained map in ArcGIS for check value, for 2 images (2009, 2019) must be in equal every class and same area and same resolution. Reclassify both map at 4 type again. (in ArcGIS). Set the Label value to an integer only. (in ArcGIS)

Return to IDRISI again. Run MAKOV Chain. Selected a base image as 2009(Ortho RGB aerial photography) compared to 2019 (image from the drone). Defines the gap of both years, 10 years and set the predicted year as the future for the next 10 years. Do not select maps from browsing button. The maps that we use must only come from the same folder we created, otherwise the IDRISI program will not calculate, all operations will be in the same folder. When we finished this MAKOV step. We get conditional probability map, transition area matrix, transition probability matrix. Class number 1 2 3 4 means Forest(F), Miscellaneous(M), Urban and Built-up(U), Water body(W) chronologically number.

IDRISI: Run program CA-Markov Model at Modeling> Environmental/Simulation Models >Time Series > CA_MARKOV.(Eastman, 2003) Selected a base map 2009 (image from the drone) compared 2 part. Use The transition area, conditional probability map that is a result from Markov chain step. Select cellular automata filter type standard 5x5 contiguity filter. The time used in calculations depends on the number of cellular automata interaction, we will get the LULC map of Sichang Island in the future for the next 10 years (dividing land use into 4 types). Export any file, file format, .img or .tiff

Check the accuracy of the prediction map by the map year 1999 compared with 2009, to predict the 2019 map. It's mean we have to generate LULC year 1999 again. The results are compared with the actual map data obtained from drone. The Drone and Ortho RGB aerial photo, result accuracy is 93.61% The satellite images Landsat 5, result accuracy is 62.68% (before use raster calculation, must resample resolution to 1 meter).

3. RESULTS

3.1. Complex risky area maps.

Complex risk maps (Integrated landslide and flood risk) have a low-risk area with a total area of 3.436 square kilometers. medium-risk with a total area of 2.648 square kilometers, high risk with a total area of 0.1795 square kilometers (2.865 %), shown in the figure 4.

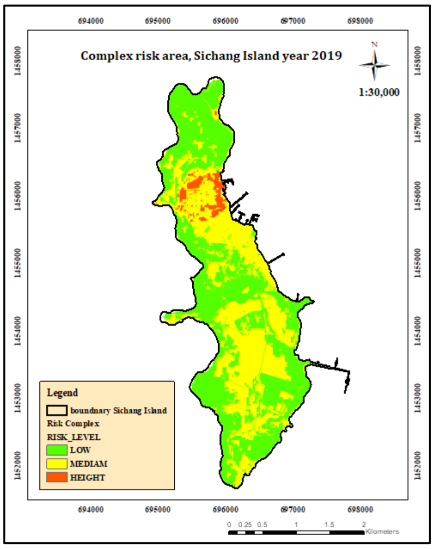

Figure 4. Complex risk area map.

3.2. Predict of changes in LULC next 10 years

Predict year 2029 of changes in LULC of Sichang Island during year 2009 and year 2019, This table describes changes LULC area. The unit is square meters, from what has changed to what, what is still the same, example is Urban-build up area from year 2019(Note the horizontal space in the letter U, number is 1,075,934 m^2) to year 2029(Notice the vertical position in the letter U, number is 1,176,780) increase 100,846 m^2. Forest and Miscellaneous area become Urban-build up area 67,7256 and 33,262 m^2, not change and still urban area 1,075,793 m^2 and change to water body area 141 m^2, results as follows:

Table 2. Transition area matrix.

Year			2029		
2019	F	M	U	W	Total(m^2)
F	3,770,646	64507	67,7256	2,056	3,904,934
M	107,654	1,264,744	33,262	1,013	1,406,673
U	0	0	1,075,793	141	1,075,934
W	0	0	0	36,685	36,685
Total	3,878,300	1,329,252	1,176,780	39,894	6,424,226

4. DISCUSSION

This research used aerial imagery from a drone is basically, divided into 2 parts, the first part is calculated for the risky area, the second part predicts the LULC for the next 10 years, which is relative with the 10-year economic development plan of Thailand as well. Using the CA-MAKOV model theory calculations(White, Engelen, & Uljee, 1997), past photographs map must be compared, an aerial photograph of 50 centimeters, Ortho RGB resolution. (researchers requesting support from the Royal Thai Survey Department). For the first time, the researcher used data from Landsat 5 satellite, which has a resolution of 30 meters, when calculating the error value was too large, so when we had the drone images, if we wanted to predict the LULC with CA-MAKOV model, the entire map image must same resolutions map. This is because the Si Chang Island area is approximately 6.5 km^2, with very little space compared to other studies, so flying drones to build a database is the right answer.

5. CONCLUSION

Complex risk maps (Integrated landslide and flood risk) have high risky area 2.9%. Which has a community area in this risky area with a total of 1 village. The Thai government agency at Sichang Island should prepare plans to accommodate future disaster situations.

LULC predictions for the next 10 years can be concluded that there is a slight decline in forest areas, less miscellaneous areas, more urban and construction areas, constant water supply areas, indicating that there is an enlargement of the city. The government should use the budget to support the construction of roads and public utilities to support the increasing number of tourists, transport and goods, environmental protection, planning to eliminate waste caused by tourists, etc.

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