Using drone mapping to support EEC development plan by analyze risky area and predict LULC at Sichang Island, Chonburi province, Thailand

SUWATCHARAPONG SURASANPREEDEE

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE MASTER DEGREE OF SCIENCE
IN GEOINFORMATICS
FACULTY OF GEOINFORMATICS
BURAPHA UNIVERSITY
2021

การสร้างแผนที่จากโดรนเพื่อสนับสนุนโครงการระเบียงเศรษฐกิจตะวันออกโดยการคำนวณหา
พื้นที่เสี่ยงภัยและทำนายพื้นที่ใช้ประโยชน์ในอนาคต พื้นที่ศึกษา อ.เกาะสีชัง จ.ชลบุรี ประเทศ
ไทย

สุวัชรพงศ์ สุรแสนปรีดี

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SUWATCHARAPONG SURASANPREEDEE : USING DRONE MAPPING TO SUPPORT EEC DEVELOPMENT PLAN BY ANALYZE RISKY AREA AND PREDICT LULC AT SICHANG ISLAND, CHONBURI PROVINCE, THAILAND. ADVISORY COMMITTEE: ZHENFENG SHAO, Ph.D., KITSANAI CHAROENJIT, Ph.D. 2021.

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). Still, 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 in the sea, Sichang Island (located in Chonburi Province) has sufficient potential for development. One of the EEC policies will also be subject to spatial development too. This research study the knowledge of Geoinformatics, remote sensing, and aerial imagery from the drone are used to research to determine the potential of the development of the Sichang Island area. These include finding risky areas on the island[1] and predicting future LULC in the next 5,10,20 years (The numbers are related to the Thai National Strategic Plan)[2] by using aerial imagery from drones as a base. We obtained the results, has a village in the community in risky areas (flood and land-slides combined), and the prediction of the future LULC is the continuous expansion of urban-build up area. The study results for the risky areas (high level) were 179,503 square meters or 2.8655 % of the total area. Prediction of LULC changes in the next 5, 10, and 20 years tends to increase the number of residential areas, miscellaneous areas, decrease, forest areas slightly decrease, stable water areas. In the next 5 years, the residential area will increase by 90,258 square meters. The miscellaneous area is reduced to 47,570 square meters. The Forest area has decreased by 42,760 square meters. In the next 10 years, the residential area will increase by 100,899 square meters, and the miscellaneous area will decrease by 76,400 square meters. The reduced forest area is 24,580 square meters. In the next 20 years, the residential area will increase by 296,546 square meters. The miscellaneous area is reduced to 154,855 square meters.

The forest area has decreased by 134,988 square meters.

The main contents of this thesis include the base map from flying drones to create very high-resolution images, Classification of the risky levels. Remote sensing (RS), geographic information system (GIS), and the principles of Potential Surface Analysis (PSA) weights are calculated from the Analytic Hierarchy Process (AHP) by determining the factors involved in each type of disaster. Analyze to find risky areas, and the last one is Using the CA-MARKOV model to Predict LULC in Sichang Island in the years 2024,2029,2039.

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CHAPTER 1

INTRODUCTION

1.1 Statements and significance of the problems

Thailand's government wants to be an economic leader in Southeast Asia. It has been implementing long-standing plans, beginning with the Eastern Seaboard Project for 30 years, continuing the second project, the Eastern Economic Corridor or EEC (Emparanza, Hongkarnjanakul, Rouquette, Schwob, & Mezeix, 2020; Tontisirin, Phoomikiattisak, & Anantsuksomsri, 2017). which uses three provinces in the eastern region as a template, with the development plan focus on industrial structure development, construction, communication, etc. They focus on the mainland to develop that area. The government has the condition that it must be the area that can extend for authentic, sustainable, and sufficient capacity. Sichang Island is considered qualified because the Island is unique in tradition and culture and is a tourist attraction. It is also near to Bangkok, able to make a One Day Trip. The Island takes time only 45 minutes from the mainland. The researcher, therefore, agreed that and I should use geographic information knowledge to study Sichang's information with the understanding that it consists of remote sensing and geoinformatics Systems. But there is a limitation that Sichang has a small area. We cannot use satellite image data to solve all problems. Must have precise, high-resolution aerial imagery data. So uses unmanned aerial vehicle (UAV) to collect data along with satellite images as well.

Aerial imagery is essential information technology data used in urban design or LULC classification of area utilization. The researcher can obtain from various image databases such as satellite images. Aerial photos from the website or requesting support from government agencies but such information have limitations such as insufficient resolution in planning analysis. Too old information can often not be used properly. In addition, if the aerial imagery is to be reproduced, it will cost a lot, and there will be some restrictions on the use of data for area analysis. Therefore, the application of unmanned aerial vehicles to self-generated aerial imagery for urban design is a new approach tool, a substantial alternative, able to gain a deeper

understanding of the urban and environmental context. In Thailand, government agencies have just started making maps based on unmanned aircraft. This research provides a basic, easy-to-use process for creating rapid aerial photography for urban design with low-cost (commercially available) unmanned aerial vehicles as well as aerial photography techniques. That can be quickly done in this step, the preparation of aerial imagery covering a wide area. Still, it is considered very small compared to satellite images using the study area, namely Sichang Island, Sriracha District, Chonburi Province.

1.2 Research objectives

The main objective is determining the potential for the development of the Sichang Island area begins with the acquisition of aerial imagery data and is then analyzed and converted into a polygonal or raster file format. To start with, the FGDS database is created based on the drone imagery, after which it calculates the hazardous area and predicts the future utilization area concerning the EEC economic development plan.

Specific objectives

1. Collecting data and create new FGDS layer from drone image in Sichang Island, Chon Buri province, Thailand.

2. Assessing the location of natural disaster risky areas (landslides, floods).

3. Predict land use land cover for next 5, 10 and 20 years.

1.3 Research Question

1. What is the process for using Drone to create very highly resolution image at Sichang Island?

2. What are the advantages and disadvantages of FGDS derived from Drone images?

3. Where are risky areas (flooding and landslides) at Sichang Island?
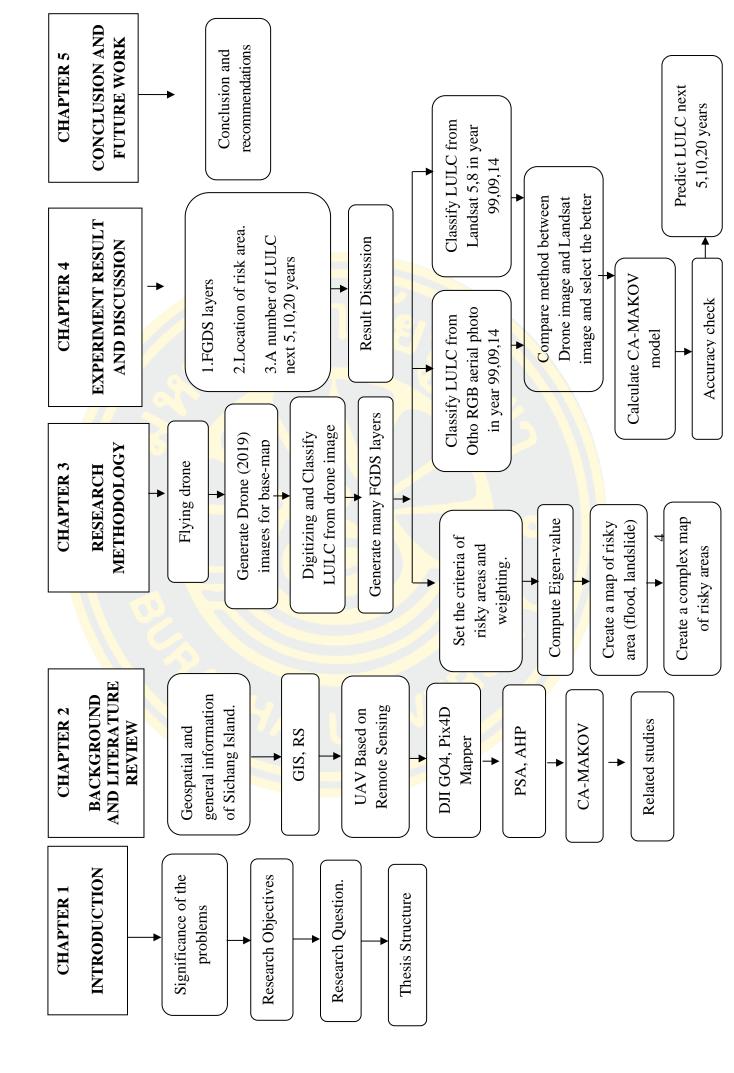
4. How are the LULC of Sichang Island in the next 5,10 and 20 years?

1.4 Thesis Structure

The structure is as follows:

Chapter 1 presented the statements and significance of the problems of EEC development plan at Sichang Island, Chonburi province, Thailand by using drone mapping analyze risky area and predict LULC including research problems and objectives of the study.

Chapter 2 will provide an overview, Literature review topic about Sichang Island, GIS, RS, Drone, Application DJI GO4, Application Pix 4D mapper, Risky area, PHA, AHP, CA-MARKOV model, and related studies with risky area in Thailand or other countries, Predict LULC area in the future. Chapter 3 will describe the techniques used in this study area and methodology. Next, chapter 4 represents the results of the FGDS layers, Location of risky area, LULC next 5,10,20 years. Finally, the last section will conclusion the results of drone mapping to support EEC development plan.

CHAPTER 1
INTRODUCTION

- Significance of the problems
- Research Objectives
- Research Question.
- Thesis Structure

CHAPTER 2
BACKGROUND AND LITERATURE REVIEW

- Geospatial and general information of Sichang Island.
- GIS, RS
- UAV Based on Remote Sensing
- DJI GO4, Pix4D Mapper
- PSA, AHP
- CA-MAKOV
- Related studies

CHAPTER 3
RESEARCH METHODOLOGY

- Flying drone
- Generate Drone (2019) images for base-map
- Digitizing and Classify LULC from drone image
- Generate many FGDS layers

- Set the criteria of risky areas and weighting.
- Compute Eigen-value
- Create a map of risky area (flood, landslide)
- Create a complex map of risky areas

- Classify LULC from Otho RGB aerial photo in year 99,09,14
- Classify LULC from Landsat 5,8 in year 99,09,14
- Compare method between Drone image and Landsat image and select the better
- Calculate CA-MAKOV model
- Accuracy check
- Predict LULC next 5,10,20 years

CHAPTER 4
EXPERIMENT RESULT AND DISCUSSION

- 1.FGDS layers
  2.Location of risk area.
  3.A number of LULC next 5,10,20 years
- Result Discussion

CHAPTER 5
CONCLUSION AND FUTURE WORK

- Conclusion and recommendations

CHAPTER 2
LITERATURE REVIEW

The application of geographic information systems (using small unmanned aircraft is mainly) in area Sichang Island apply geographic information systems. With potential surface analysis and overlay analysis to analyze and assess the risk of natural disasters (landslides, floods) and classify risk levels. Predicting land use land cover trends in the next 5, 10, 20 years (2024, 2029, 2039). In order to prepare geographic information for supporting the master Plan EEC mega project, this research study-related documents, theoretical concepts, including as follows:

1. Basic physical and social information of Sichang Island.
2. Geographic information system (GIS)
3. Remote sensing (RS) definition.
4. Drone.
5. DJI GO4, Pix 4D mapper.
6. CA-MARKOV model.
7 PSA, AHP
8. Related research results.

2.1 Basic physical and social information of Sichang Island

The smallest district in Thailand but there are many definitions. A tiny sub-district named Tha Thewawong, 12 kilometers away from Si Racha District, takes about 30-45 minutes. The area of the island is 6.5 square kilometers. The population lives around 10,000 people/day, despite being the actual population and latent population. The majority of the people are Buddhists. This island has been known since the Ayutthaya period. With good fresh air, in the past, the reign of King Mongkut (Rama 4) come here and at that time, and his son King Chulalongkorn (Rama 5) went together, therefore, the name Sichang Island very famous since then (The King of Thailand in the present dynasty is King Rama 10)

The administrative area has an area of about 6.5 square kilometers. Sichang Island has a location in the Gulf of Thailand, opposites Siracha district, Chonburi province and approximately 12 kilometers, far away from Bangkok around 117

kilometers, which has the following territories with neighboring districts and areas. North to sea, Mueang District, Samut Prakarn Province, South to sea, Bang Lamung District Chonburi province, East to sea, Si Racha District Chonburi province, West to sea, Ban Laem District Phetchaburi Province.
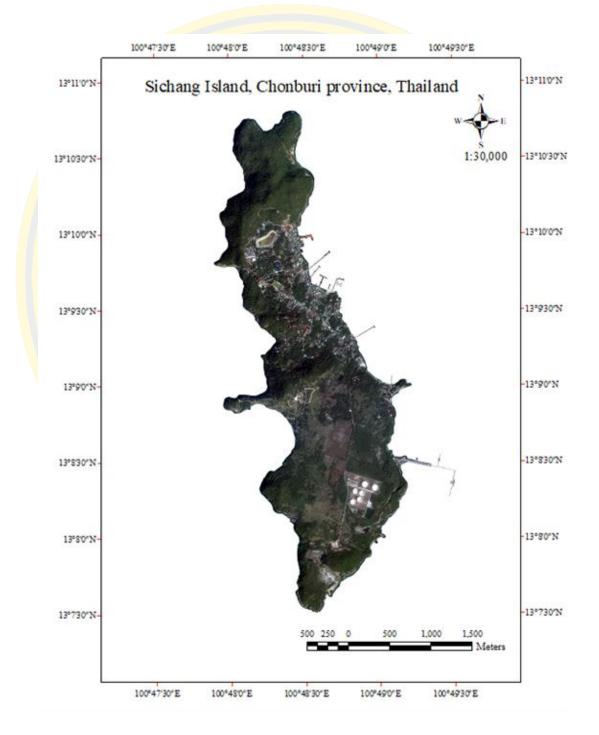
Figure 1 Location and territory Sichang Island

Total number of houses in the area of responsibility 2,093 houses. Total population 4,580 people divided into Men 2,267 people. Female 2,313 people.

Table 1 Type of population and number of male and female

Type	Male	Female
Children (Infants - 9 years)	258	241
Older children (10-14 years)	156	136
Adolescents (15-19 years)	154	110
Adult (20-59 years)	1,411	1,711
Seniors (60 years and over)	285	352

Number of people with disabilities or chronic illness 108 people.
- Population density 330 people / Km2
- The rate of population growth from the year 2016-2017 is 71 %.
- There are 23 essential tourist attractions in the area of responsibility.
- Traffic 22 roads and five bridges.
- Public transportation by ship.
- Telecommunications by phone and the internet. Public telephones in the area are 15 numbers. Some telephone exchanges are 1 unit—Telegraph Post Office 1 place.
- Water supply. The number of the family using tap water is 356 families. Tap water produced is 240 m.3 / day. Tap water used is 120 m.3 / day. The raw water source used to make tap water has one place. Natural water reserves have three locations.
- Electricity. The number of a family using electricity 1,459 families. Areas that receive electricity services 99 % of the total area. Public electricity (illumination) Amount 2,764 Point and coverage 22 roads.

Income 106,218 Bath/ person / year. Commerce and services, gas stations are 9 locations Fresh market 25 of places. Commercial establishments. Jetty 5

locations. Tourism Number of tourist spots is 23Places. Number of tourists is 486,993 people, tourism income 316,545,450 bah / year. Number of houses is 2,093 houses. There are 6 villages consisting of Ban Tha Thewawong Community (Village No. 1) Ban San Chao Community (Village No. 2) Ban Tha Wang Community (Village No. 3) Ban Trok Dan Tax Community (Village No. 4) Ban Saphan Khu Community (Village No. 5) Ban Tha Phanurangsee Community (Village No. 6)

Religion. There are 2 Temples. Buddhist 95 % of the total population. 1 mosque, Muslim 4 % of the total population. Churches, Christian 1 % of the total population. Culture important local traditions. (1) Songkran Day in April activity brief sand pagoda making merit, giving alms, pouring water over the head of the elders, hit the clouds, carry the girl into the water. (2)100th anniversary of Sichang in September. Summary of activities. Paying royal service to the King Chulalongkorn Performing in remembrance Royal grace for the people of Sichang Island. (3) Loi Krathong Day, activity in brief Loi Krathong activity Krathong Contest.

Sport / recreation/ Public health. 1 Soccer field, 1 Basketball court, 1 Takraw field, 1 Public library and 1 Playground. 1 hospital. Capable of supporting patients up to 30 beds.

Environment and natural resources. Highest temperature 38 c̊ Lowest 25 c̊. Average temperature per month Mar - Jun. 40 c̊. Average temperature per month Jul - Oct 35 c̊. Average temperature per month Nov - Feb 28 c̊. Waste water about 3.350 m.^{3}/day. Garbage amount 12-15 tons/day.

Strategic development plan amount 7 Strategies as follows:

- Strategy Infrastructure.
- Strategy for promoting quality of life.
- Strategy for organizing community and keep calm society.
- Strategy planning promoting investment in commerce and tourism
- Strategy for management and conservation of natural resources and the environment.
- Strategy religious art and culture and local knowledge.
- Strategic management and support the mission of civil service and local government organizations.

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2.2 Geographic information system

2.2.1 GIS Applications

People have used maps for centuries already. In the last twenty to thirty years with the deployment of computer science and information technology(Bonham-Carter, 2014) could progress fast and be applied in a Spacious area. The map can use it almost everywhere. It became a part of keystone business and management affairs worldwide in organizations as diverse as municipalities, state government, utilities, telecommuting, railways, civil engineering, petroleum exploration, retail, commerce, etc., both in the private and the public sector. This array of institutions being merged GIS into daily operations and the applications involved in these systems are equally important, from infrastructure management to vehicle routing, site selection, research, and analysis. The basic information for almost each application area is the same: geographical data of a specific area of the world with information depending on the user's demand to that area. The principal data for each application in the geographical location is: relief, hydrography, and already built infrastructure (roads, railway, settlements, etc.)

The thematic information, which uses GIS, is put above this information to gain data related to our thematic. The difference can be the resolution needed or information needed of the map source for a particular application. In its early times, the military force has used GIS software for exploration, mission planning, accident investigation, wargaming, simulation. The first point of using GIS was to deal with land, real estate management, urban planning, and infrastructure. The advantage of GIS is the data storage, cost savings, transparency, possibility of simulation, and quick and precise decisions. But in the era of the information society, information theft and the cracking of websites can be dangerous for GIS information put on the Internet. In the following section, some GIS applications are detailed.

2.2.2 GIS in disaster management

"Disaster" is a phenomenon related to the area. This is because a disaster will damage resources, property, and people in a particular area and affect the surrounding area. Therefore, technology and information related to spatial management play an essential role in disaster management, which is "geo-information technology." (Abbas, Srivastava, Tiwari, & Ramudu, 2009)Geographic Information

System (GIS), Remote Sensing Technology, and Global Positioning System (GNSS) Geospatial technology can be applied to support disaster management at all stages, which is a continuous process divided into 4 phases: preparation before the accforestdent planning and mitigation emergency response and finally, the post-revival. Many organizations around the world are now adopting geographic information systems (GIS) to support spatial decision-making. To deal with widespread disasters due to the disaster risk assessment, the assessor needs to have a first-hand understanding of the nature of the disaster situation, such as the affected area. (Area of the epicenter, the place where the storm lands), physical characteristics (Earthquake intensity, storm pressure center), local conditions (land use, the type, height of the building in the affected area), etc. Such properties require an understanding of the geographic dimensions of the affected area. To be able to predict the severity of damage that will occur in the future. Understand the impact this can have on the building. Infrastructure and population in the area at the same time, the information is helpful to aid evacuation and rehabilitation as well. Therefore, geospatial information is essential for effective disaster management planning, back before introducing geospatial technology. Decisions regarding disaster management are based on the experience and competence of the decision-maker, rather than fact-based decisions reflected through data. But nowadays, geospatial information such as topographic information, Population data infrastructure information. It contributed significantly to aid and damage restoration. GIS today can work with a wide variety of data formats. It is also easy to access through the internet. They were helping the timely dissemination of information critical to disaster response. In addition, the staff officer can make decision-making more rapidly. Some countries with advanced technology have laid the foundations for applying geospatial technology in all phases of disaster management. Since preparation, Planning, mitigation, response, remediation, and link phases of information into the same system for continuity of information, support decisions, and operations.

2.2.3 GIS for Urban Planning

GIS for Urban Planning.(Yeh, 1999) Application of GIS to assist in land use planning. It is one of the most widespread GIS application activities. Because of their ability to analyze, evaluate and present various spatial information necessary for

urban planning and city management can be done conveniently by examining and evaluating the utilization potential of each area.

2.2.4 Military and Defense Applications of GIS

Military and Defense Applications of GIS.(Swann, 1999) It plays a pivotal role in military and Defense operations as they are essentially spatial. The concepts of Command, Control, Communication, and Coordination in military and Defense operations are primarily dependent on accurate information to arrive at quick decisions for operational orders. An essential role for Battlefield management, terrain analysis, remote sensing, military installation management, monitoring of possible terrorist activity, mission planning.

2.2.5 GIS in public health

Information technology and the development of public health(Cromley & McLafferty, 2011). Information technology has been used extensively in developing public health, enabling the rapid advancement of public health work. Information is used in various positions. As follows: the registration of patients, starting from the beginning of the registration of the ID card, drug dispensing, treatment bill payment, medical support. By linking the computer systems of different hospitals together, it can create a network of medical information. Exchange patient information and provide remote consultations (by doctors specializing in information technology) allow the doctor to see the patient's face or gesture and send documented or visual information for the doctor's consideration. Yes, educating people of doctors or public health agencies is more convenient, faster, and more effective by using media such as still images, animations, sounds, etc. Information technology allows administrators to formulate policies and follow up. To better monitor policy operations by relying on accurate, timely, and necessary information, they may use computers to collect data, making management possible faster and more accurately. In education or distance learning, information technology, especially satellites, will help make distance learning in medicine and public health more feasible, and people can learn simultaneously throughout the country. And You can also respond or ask questions.

2.2.6 GIS Based on Vehicle Tracking (Navigation)

GIS system applied for navigation(Taylor, Blewitt, Steup, Corbett, & Car, 2001; ZHAI & CAI, 2004) GIS Based on Vehicle Tracking (Navigation), GIS system

applied for navigation[10, 11] is in continuous development since the time GPS started. To gain, handle, store and display dynamically changing information in real-time, a unique device must maintain the changes based on a geographic information system for transportation equipped with a satellite positioning device. Within the system, there will be many forms. The general model is that users have a GPS receiver that displays their vehicle's location and a map installed with or receives a signal from a mobile phone on the Internet. Which way to go Another form is a system to use for transportation management. A GPS receiver is built into the car to see if the driver has followed the set route. The system can control oil consumption when the repairman should repair it. Change engine and prevent car theft by notifying the control center to be able to order cutting off the oil system GIS implementation in transportation management or delivery aspect is more critical In cost It is essential for the planning of the delivery of products from the production site to the factory, from the processing plant Delivered to the warehouse, from warehouse to market, and from market to consumers on time, reducing product damage and in the process. If able to reduce the cost of transportation Will reduce costs and can generate profits.

2.2.7 GIS for Buildings

GIS for Buildings.(Yeh, 1999) This type of GIS is not the traditional GIS-based on geographical information. Based on the parameters of buildings, coordinates, and spatial information of buildings. It is a new application area and still in its infancy. It is applied in Warehouse management and Architecture. It is essential for information about where the items are located and tracking the movement of the items within a building.

2.3 Remote Sensing (RS)

Remote sensing(Rogan & Chen, 2004; Zhang, Zhang, Du, Kang, & Qiao, 2017) is the science (to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information.

In much remote sensing, the process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging

systems where the following seven elements are involved. Note, however, that remote sensing also consists of the sensing of an emitted energy and the use of non-imaging sensors.
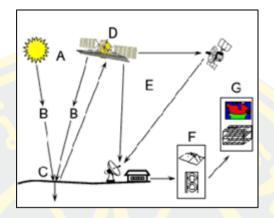
Figure 2 Remote sensing process.

Remote sensing process.

1. Energy Source or Illumination (A) - the first requirement for RS is to have an energy sources that illuminate or provide electromagnetic energy to interested targets. Radiation and the Atmosphere (B) - as the energy move from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy move from the target to the sensor.

2. Interaction with the target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

3. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

4. Transmission, Reception, and Processing (E) - the energy noted by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

5. Interpretation and Analysis (F) - the processed image is comprehended, visually and/or digitally or electronically, to extract info about the target which was illuminated.

6. Application (G) - the final element of the remote sensing process is achieved when we apply the data, we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

2.4 Drone

Drones or unmanned aircraft or UAV (Unmanned Aerial Vehicle) (Newcome, 2004) were used initially in security agencies. At present, it has been used in various forms such as agriculture, surveying, building inspection, transportation, surveillance, aerial photography, creating 3D maps, and being used for playing as a hobby. 2. Helicopters (Single rotor) 3. Plane drone Multi-rotor Vertical up and down, which have different pros and cons. Depending on the suitability of use, which is currently used in aircraft, drones. Multi-rotor Up and down vertically Let's help with aerial photography in more mapping. Due to minor maintenance, Lightweight, easy to carry, suitable for beginners. Until professional Planning for the development of the area or the use of the land. Geographic Information System (GIS) is widely used. Some of the information changes frequently. The presence of spatial data or maps that are up to date. It allows for agile and efficient planning concerning that area. Both in terms of timing and accuracy, Aerial photography highlights. It is that aerial photography can show the broader and highlight of the site. And from being a still image recording, it is a time recording that will last forever. It can be used to analyze current conditions (Existing Area) in terms of remote sensing. Aerial imagery can also capture wavelengths and details that the human eye cannot see. And better classified as well the final highlight is the accuracy and reliability of the information. This makes it possible to be used to reduce the time in the field survey as well.

Figure 3 DJI Phantom 4 Drone image source DJI

The Phantom 4 (Iqbal, Alam, Kazim, & MacDermott, 2019; Taddia, Stecchi, & Pellegrinelli, 2019) drones can fly at speeds of over 72 km / h in sport mode and have a range of up to 7 km (depending on wind and noise) while delivering a 1080p quality live image signal, including automatic switching with the newly developed 2.0 system. It has a maximum flight time of about half-hour, so we can be sure that We'll have plenty of time to get the best capture of the images, and the DJI GO 4 app will automatically calculate the remaining flight time. It will alert whenever the battery level is approaching the return flight limit, a 5-way obstacle sensor, enhanced safety in the return flight, and an advanced power management system to prevent malfunctions of battery.

Figure 4 DJI Mavic Pro Drone. Image source DJI

Drones with the introduction of new technology and the camera are of the same high quality as the Phantom 4 Pro, which is almost the same size as the previous Mavic Pro drones while also having the same weight. The Mavic Pro weighs in at

15

734g, while the Mavic 2 Pro only weighs 907g, giving the Mavic 2 Pro a 31minute long battery life. Easy to carry and can be folded up like before. A new obstacle sensor system is installed. To detect obstacles or obstacles in all directions (Omnidirectional Obstacle Sensing System) makes it safer and more confident while flying the drone. The sensors on the left and right of the Mavic 2 Pro will only work in Tripod and Active-track modes, and an infrared sensor is also added at the top and bottom. To help with flight in tight spaces and improve movement accuracy, the Mavic 2 Pro supports APAS (Advanced Pilot Assistance Systems), enhancing safety during a drone flight. This system works when the drone detects an obstacle during the flight path. Drones will be able to avoid those obstacles automatically. Improved and developed a new video transmission system known as the Ocusync 2.0 system, which enables 1080P video transmission at a flight distance of up to 8 kilometers. The Mavic 2 Pro also supports a 2.4 frequency band. Up to 5.8 GHz can be auto (Auto-Switching). Explained the drone could adjust the frequency range automatically. For better signal transmission, the Mavic 2 Pro also designed a new T / P / S flight mode switch to allow quick flight mode switching in just a few seconds. Object tracking systems for increased accuracy and efficiency than ever before. By the name of Active-track 2.0 is a system that can detect and track the objects we want. The original system was a 2D motion capture system, but the new Active-Track 2.0 combines the primary camera and sensor system functionality. To be able to capture the movement of objects in 3D, it is highly accurate and precise.

Figure 5 DJI Flame wheel Drone Image source DJI

The DJI F550 is a custom-built multi-rotor drone designed with mission flexibility in mind. It is a large stable platform for aerial photography and video

shooting. Base frames can be easily modified to accommodate various cameras, gimbals, and support devices. All six motors provide enough power to carry a weight of up to 300g, a maximum flight time of twelve minutes, depending on the load. If there is a lot of load in the air, it will be less when operating in the air.

2.5 DJI GO4 and Pix 4D Mapper application

2.5.1   Application DJI GO4

DJI GO 4 is an easy-to-use app for using drones. Beginners can also savvy. This can be managed as a standalone remote control for the Spark and Mavic Pro or in federation with a remote controller for the Phantom 4 Series, Inspire2, Spark, and Mavic Pro. Overall, the app is your gateway to a drone setup. Therefore, it is significant to know how the settings work. The basic setup steps are as follows.

Figure 6 Application DJI GO4, basic Screen display

1. System Status: This icon shows UAV or drone flight status and demonstrates many warning messages.

2. Obstacle Detection Status: The red tab is shown when a hazard is close to the UAV. An orange tab is shown when the hazard zone in the detection range.

3. Battery Level indicator: The battery level indicator shows the battery level dynamically. The colored zones on the battery level indicator indicate the level of energy required to perform the functions.

4. Flight Mode: The text next to this icon stipulates the present flight mode. Tap to configure the master controller settings. These settings allow you to remodel flight limits and set gain values.

5. GPS Signal Strength: Show the present number of connected GPS satellites, and the white tab shows enough GPS signal.

6. 3D Sensing System Status: Tap this icon to enable or disable features provided by the 3D Sensing System

7. Wi-Fi Settings: Tap to enter Wi-Fi settings.

8. Battery level: This icon shows the current battery level. You can tap to view the battery information menu, set various battery warnings (remaining battery charge), and view the battery warning history.

9. General settings: We can tap into the common settings menu to set metrics, enable live streaming, and display flight routes.

10. Gimbal: The slide shows the volume of the gimbal.

11. Switch Photo/ Video: Tap to switch between Photo and Video recording modes.

12. Capture/ Record button: Tap to start taking photos or recording videos. Choose either.

13. Camera settings: Touch to enter the general camera settings menu.

14. Playback: Tap to enter the Playback page and preview the photos and videos as soon as they are captured.

15. Flight Telemetry: This zone shows flight data such as flying speed.

16. Virtual Joystick: Tab this to show the virtual joysticks to control the aircraft via the touchscreen on your mobile device.

17. Intelligent Flight Mode: Touch to select Intelligent Flight mode.

18. Smart RTH: Initiate RTH (Return to home) procedure. Tap to have the aircraft return to the last recorded home point.

19. Auto Take Off/ Landing: Touch to initiate auto take-off or landing.

20. Back: Touch this icon to back to the main menu.

Flight Mode. The program can show 3 flight modes in the DJI GO 4.

Positioning mode (P-mode). P Mode is when all the drones' sensors are enthusiastic, so the drone should normally be steady. This is the safest mode to fly the drone in as if you take your hands off the control sticks, and the drone will automatically stop moving and float in position.

Attitude or ATTI mode (A-mode). The drone will switch to ATTI mode if there is no GPS semaphore or a vulnerable signal, and it is too dark for the vision systems to operate. The aircraft will only maintain its altitude, but it will stroll—sport mode (S-mode). Sport Mode, your drone can fly at full speed while using GPS for deposition. However, the forward and downward vision systems will be disabled, so the aircraft will not recognize and avoid obstacles.

2.5.2   Pix 4D mapper program

Pix 4D mapper (ZHOU, HE, & SHEN, 2019) is an aerial photo mapping application from drones prevalent. It aims to bring aerial images from the drone to do something in many ways, and here are the various image processing capabilities the drone can do. RGB, NIR, and RedEdge image processing. Create anchor points for spatial coordinates from aerial laser scanning. DSM / DEM surface construction with a high level of detail in TIN or GRID format. 3d modeling. Orthophotos visualization of length, area, and volume.

Step of using PIX 4D application

Before Starting a Project. The dataset (compulsory images optional but the excellent way introduced ideas geolocation and Ground Control Points (GCPs)) has to be gained on the field before using Pix 4D mapper. A good dataset is required to create results with high quality and accuracy automatically. To take a good dataset. Designing the Images Acquisition Plan, it is essential to design a good image acquisition plan considering, Type of project (aerial, terrestrial, mixed). Type of terrain/object. Type of camera. Purpose of the project. Image rate that the images are taken. Distance (flight height) at which the images are taken and with which angle to take the pictures. Path(s) to follow to take the photos.

This also implies selecting a corridor path or regular grid and circular grid for aerial projects and deciding whether we will use terrestrial images. If more than one flight is needed to cover the whole area, design the area to cover each flight.

To automatically get high accuracy results, a high overlap between the images is required. Therefore, the image acquisition plan has to be carefully designed to have enough overlap. The image acquisition plan depends on the required GSD by the project specifications and the terrain type/object to be reconstructed. A lousy image acquisition plan will lead to inaccurate results or processing failure and will require the acquisition of images again.

Pix 4D mapper is an image processing software based on automatically finding thousands of common points between images. Each characteristic point found in an image is called a key point. When two key points on two different images are the same, they have matched key points. Each group of correctly matched key points will generate one 3D point. When there is a high overlap between 2 images, the common area captured is larger and can fit more key points together. The more key points there are, the more accurate 3D points can be computed. Therefore, the main rule is to maintain a high overlap between the images. As the image acquisition plan has a high impact on the quality of the results, it is essential to design it carefully. Below is described the recommended different image acquisition paths and overlap for other cases. Even though it may work with lower overlap than the suggested ones, it is meant to use the recommended overlaps to obtain the best possible results. In the General case, the recommended overlap for most cases is at least 75% frontal overlap (with the flight direction) and at least 60% side overlap (between flying tracks). It is recommended to take the images with a regular grid pattern. The user should maintain the camera as much as possible. A constant height over the terrain/object to ensure the desired.
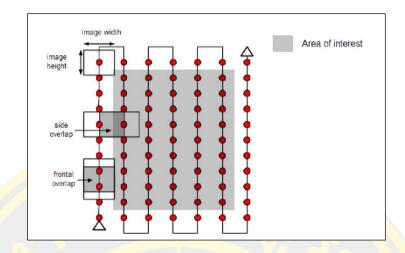
Figure 7 Ideal Image acquisition Plan – General case

The flight height should not be increased more than twice between the flights, as different heights lead to other spatial resolution. Pix 4D mapper generates a high-quality point cloud for oblique images of buildings. However, no orthomosaic image is generated when the selected template is 3D.

2.6 The Ca-Markov model

2.6.1 The Ca-Markov model

The CA-Markov model predicts land-use dynamics using a mathematical model in conjunction with the geospatial system. In the past, it only showed quantitative results. Each model has a different working process but can study land-use dynamics and spatial cover. The Ca-Markov program is an IDRISI sub-program, a simulation where the area is divided into subunits to make the most homogeneity. And each unit has a behavior of each process, such as rainfall, soil erosion, etc. According to the nature of each area, these vary systematically linked the results from each unit together with the following principles.

1. CA-Markov's data analysis process uses the opportunity of change data obtained from the Markov Chain Analysis with the CA Filter 5X5 (Neighborhood) to determine the probability of the soil cover at the time required. study

2. CA Filter will overlap with the data area of the study year, one cell at a time to complete the study area. They will begin to overlap one cell simultaneously

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and will continue to move continuously for a number. The cycle is equal to the period of study

   3. For each iteration, the type of LULC will change or remain in its original state depending on the surrounding LULC. This is based on The Game of Life theory and the likelihood of change obtained from the Markov chain analysis.

   4. At the end of the process, the result is a LULC map consisting of an unchanging region and an area that has changed. In which we will be able to characterize land-use changes, enabling future land use planning.

  2.6.2 Markov chain model.

   A study to predict changes in the use of LULC(Kemeny & Snell, 1976; Tontisirin et al., 2017). In the past, it was quantitative transformation, as they did not yet use geospatial systems in the study of models. Today it is popular, the Markov Chain model, which looks for the LULC pattern and rate of change with the evolutionary nature of change. And have a pattern to use this method, we must know the proportions of LULC at least two periods of time and are modestly apart and consider the probability of variation (p) of various forms of land use from one time to another. By multiplying the probability of change in matrix form with the proportion (v) of the next phase of LULC space, the duration of the third period can be calculated by the time interval between the 1 and 2, 2 and 3 should be equal. Continue this practice until you reach the fourth and fifth phases until the required time for the LULC assessment. By multiplying the probability of change in matrix from the proportion of the LULC area. The equation is as follows:

$$s(t + 1) = P_{ij}S(t)$$

Where:

  - s (t + 1), S(t) is the state at time t or t + 1

  - P is the matrix of the probability of change calculated from the equation.

$$P_{ij} = \begin{bmatrix} P_{11} & P_{12} & ... & P_{1n} \\ P_{21} & P_{22} & ... & P_{2n} \\ ... & ... & ... & ... \\ P_{n1} & P_{n2} & ... & P_{nn} \end{bmatrix}$$

Where:

- $(0 \leq P_{ij} < 1$ and $\sum_{j}^{n} = 1$, $P_{ij} = 1,(i\,j = 1,2,\ldots,n))$

2.6.**3** Cellular Automata model

Cellular Automata model(Tontisirin et al., 2017; White, Engelen, & Uljee, 1997) . It is a model that looks like an independent grid or cells. The table size is 3x3 or 5x5. It can be changed using the game of life theory. Which is a process for predicting trends of LULC change by using probability combined with environmental information. That can be displayed spatially by determining the city, area, district, or Neighborhood to define surrounding cells to enter the simulation.

Figure 8 Game of life theory**(Adamatzky, 2010)**.

2.7 PSA and AHP Online System

2.7.1   Potential Surface Analysis (PSA) theory

Potential Surface Analysis (PSA)(Ativitavas & Thongsukplang, 2006) is an area analysis using linear equations for planning the optimal space utilization by converting the displayed area into a number. (Representation of the figure with numbers) by giving the weight and score values of each factor used in the study (Samo and Anka, 2009) with the following equations.

$$S = \sum W_i \, R_i$$

Where:

- S is the suitability of the area potential.
- W_i is the total weight of factor i.
- R_i is the total score of factor i.

The Raster format is calculated by calculating each factor in the Raster format and then calculating each factor to find the appropriate area.

Substituting values from formulas: $S = (W_1R_1) + (W_2R_2) +... + (W_iR_j)$
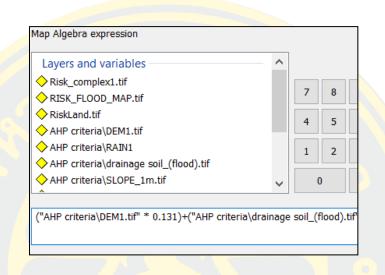
Figure 9 AHP Examples for different decision hierarchies.

2.7.2 AHP Analytic Hierarchy Process

This thesis has selected the AHP(Jin-Yu, Zhong-bin, & Qing-yun, 2008) solution on this free website as a support tool for the decision-making process. These programs are helpful in the work of simple decision-making problems and also support complex decision-making problems. Participate in group sessions and try some practical examples. AHP stands for Analytic Hierarchy Process. It is a method to support multi-criteria decision-making, originally developed by Prof. Thomas L. Saaty (Vargas, 2011). AHP derives ratio scales from paired comparisons of criteria and allows for some minor inconsistencies in judgments. Inputs can be actual measurements but also subjective opinions. As a result, priorities (weightings) and a consistency ratio will be calculated. Internationally, AHP is used in a wide range of applications, for example, for evaluating suppliers, in project management, in the hiring process, or the evaluation of company performance. It is convenient and fast, and it is also accurate.

The benefits of AHP as a decision support tool can help better understand complex decision-making problems. While you have to structure your problem in hierarchies, it forces you to think through the problem, consider the possible decision criteria, and choose the most important criteria relevant to the decision-making objectives. The use of dual comparisons helps discover and correct logical inconsistencies. This also helps to "translate" personal opinions, such as preferences or feelings, into measurable numerical relationships. AHP helps make rational decisions and makes them more transparent and understandable.

The mathematical method is based on solving the Eigenvalue value problem. The results of the double comparisons are arranged in the suitable Eigenvector matrix. The first (dominant) normal right Eigenvector of the matrix will give the ratio scale. (Weighting) Eigenvalues define the AHP sample consistency ratio, make this method easier to understand, and show a broad range of possible applications. We give some examples for the different decision hierarchies.
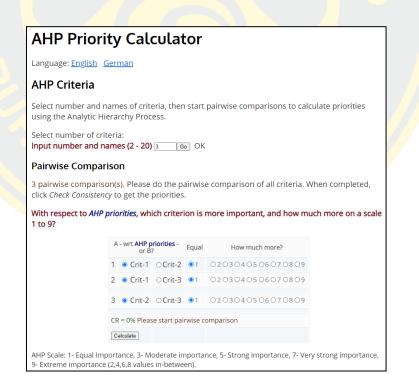

Figure 10 AHP examples for different decision hierarchies.

2.8 Related research

Sawettachat Srisurat (2014)(รัตน์, 2014) Drought risky area analysis in Nakhon Nayok province, This study has the objectives for lessons to find the method and the process in using Geography Information System (GIS), to produce a map of the area that affected by drought risks. This can be making plans and will manage to decrease and protect the damage of natural resources and the environment. In the analysis of drought risk levels in each area.

Thirawet Limkomolvilas (2014)(วิลาศ & เวทย์, 2014) Lam Takhong River Basin Land Use Prediction in 2024 with the Model CA-MARKOV. Lam Takhong River Basin (LTW) is vital because LTW is the origin of the Moon River and the type of land use. Forest, agriculture, and large urban areas (such as Nakhon Ratchasima Municipality) appear from the site. He can use the role of Landsat satellite imagery to track changes in land-use changes. This research uses 5 or 8 Landsat satellites to determine land use in three periods: 1991, 2002, and 2013. It was 11 years. Land use categories in LTW were divided into five categories: housing, forest, agriculture, water, and other areas. CA-MARKOV was used to predict land use in the area. Urban and forest were 9.71 and 24.99 percent, respectively.

In contrast, the area study will reduce agriculture, water, and other areas at 60.90, 2.27, and 2.12 percent. The accuracy of the CA-MARKOV model is 70 percent. This research is similar to this thesis. The study area is 3,318 square kilometers, approximately 500 times larger than this research, so that he can use all data from LANDSAT satellite images.

Teerawate Limgomonvilas(2014) (รัตน์, 2014)The Lam Takhong River Basin is important because the Lam Takhong water group is the origin of the Moon River. There is a wide variety in the use of land, including forest land. Agricultural area to large cities, such as the City of Rajasima, for example, a rapid increase in urban expansion or a significant decline in agricultural areas, we can use Landsat imagery to help track such changes. And classification of land use in the past to present (B.E. Land use is divided into five categories: housing, forestry, agriculture, water sources, and other areas. With the accuracy of the Moon classification equal to 80%, the Moon obtained from the classification of land use scenarios T The use of land, residence,

forest area, and water area tends to increase by 8.42%, 7.65 and 1.42% of the Lam Takhong River Basin, respectively. The agricultural area tends to decrease by 18.06% due to forecasting the proportion of CA-MARKOV model of Lamtakong River Basin in 2024 found that Use of land. Forest and forest area increased 9.71% and 24.99% respectively, while agricultural areas Water area and other areas. There is a downward trend of 60.90%, 2.27, and 2.12, with the accuracy of the CA-MARKOV model of 70%.

Asfa Siddiqui, Almas Siddiqui, Sandeep Maithani (2017)(Siddiqui et al., 2018) Urban growth dynamics of an Indian metropolitan using CA Markov and Logistic Regression. is a state in northern India. With roughly 200 million inhabitants, it is the most populous state in India and the most populous country subdivision in the world. In this study, he analyzed the urban growth within the planning area for 1993, 2003, and 2013 using certain bio-physical and proximity factors affecting the city's growth pattern. He generated factors maps for the different years, and he predicted the growth for the year 2023 using integrated Logistic Regression based CA-Markov analysis embedded in the LULC dynamics modeling. The study area is approximately 243 square kilometers, around 400 times larger than our thesis. He considered it an exciting article because he calculated external factors in conjunction with CA-MARKOV.

IDRISI Kilimanjaro Tutorial.(Eastman, 2003) Exercise 3-6 Using Markov Cellular Automata for Landuse Change Modeling. The two techniques used in this exercise to model land-use change are Markov Chain Analysis and Cellular Automata Analysis. Markov Chain Analysis is a convenient tool for modeling land-use change when changes and processes in the landscape are difficult to describe. A Markov process is simply one in which we can model the future state purely based on the immediately preceding state. Markov Chain Analysis will describe the land-use change from one period to another and use this as the basis to project future changes. This is accomplished by developing a transition probability matrix of land-use change from time one to time two, which will be the basis for projecting to a later period. From this exercise, I can use the data of IDRISI to apply it very well.

After study data from Basic physical and social information of Sichang Island, Geographic information system (GIS), Remote Sensing (RS), Basic

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knowledge of unmanned aerial vehicles (Drone), DJI GO4, Pix 4D mapper, Potential Surface Analysis (PSA), Analytic Hierarchy Process (AHP) for the calculated risky area, CA-Markov model, Relevant research, when combined with all of these, will provide sufficient basic information to figure in the third chapter. There is some other information involved in this research, but at the heart of this research focusing on the use of very high resolution from drones to support satellite imagery to help with deep data analysis until integrated into the EEC economic development plan seamlessly.

CHAPTER 3
METHODOLOGY

3.1 Study site

Areas under administrative boundaries around Sichang Island, The information in years 1999 -2019 and land use and land cover at Sichang area. I scope at data from using Satellite image data with medium resolution (Landsat 5 TM and 8 OLI). The ortho RGB aerial photography data. Town planning information facility convenient and space infrastructure on Sichang area. Some policy or vision and mission in EEC megaproject plan such as "develop an integrated infrastructure system that is efficient, reliable, and accessible to all" or "Determine the optimal use of land in accordance with the area's potential and the sustainable development principles" and "Ensure that the new city/development is modernized, safe, and supportive of business activities according to the international standard" Sichang Island located in the inner part of the Gulf of Thailand. Opposite Sriracha District Chonburi Province Located approximately 12 kilometers apart and 117 kilometers from Bangkok, the administrative area of 6.5 sq. km. In this study, which is located in the coordinates 13 ° 38′ 59″ N - 100 ° 48 ′30 E, was produced. As given in Fig 12.
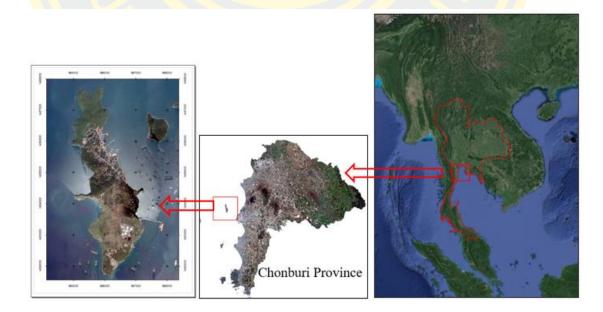
Figure 11 Study area Sivhang Island ,Chon Buri province, Thailand.

3.2 Materials

3.2.1. Instruments

Table 2 List of the material.

Materials	Objectives
DJI Phantom 4.	Flying to capture many images.
Spare batteries of the drone.	Power reserve and able to perform continuous work
GCP photogrammetric target.	To know coordinates in the area of interest.
Garmin GPS.	Navigation and Mark location.
Landsat 8 image	NDVI value for calculate Risky area.
Ortho RGB aerial photo year 1999, 2009, 2014 from Royal Thai Survey Department.	Calculate the CA-MARKOV model to predict LULC next 5 years, 10 years, and 20 years.
Drainage, lithology, precipitation data from Thai government agencies	For calculating Risky area.
IPAD, Smart phone	Display screen for drone flying.
XP-PEN Graphics Drawing Tablets	Increase the accuracy and speed of digitizing polygons.

3.2.2. Software

Table 3 The list of Software

Software	Purpose
ArcGIS program	Image processing
Pix 4D mapper program	Automatically set the flight path and take a picture. Take photos for processing.
DJI GO 4 applications	Controls the flight of a drone in general
IDRISI Selva program	CA-MARKOV
AHP website	Calculate Eigenvector for weighting Risky area.
Microsoft office program	Statistical analysis and report.

3.3 Methods

The method of study is divided into three main steps. (Depending on the purpose of the study)

3.3.1 Step 1: Data collection, divided into two subsections.

3.3.1.1 Survey and collected data.

It consists of collecting data from various sources such as satellite imagery (Landsat 5, 8), Google Earth, and at the heart of this thesis is aerial photography from drones. I will only describe the methods of flying drones to capture very high-resolution images. The process of flight surveying the Sichang Island conditions with Drone and creating maps from aerial imagery.

Drone Step 1: Preparatory steps before the survey flight

1. Fully charge the battery before every use.

2. Fully charge the remote battery.

3. Adjust the lever axis to suit the handling style.

4. Adjust the flight mode according to your usage. (It is recommended to activate in mode P because the aircraft will have the most secure flight assistance) There are 3 flight modes: P-mode, S-mode, A-mode.

5. Connect the smartphone with the cable to the remote control to use the DJI GO 4 app.

6. Check the transmitter setting position of the remote.

7. Calibrating the drone compass.

7.1. Access the status bar in the app and select "Calibrate."

7.2. Hold the aircraft vertically and rotate it 360 degrees.

7.3. Hold the aircraft horizontally and rotate 360 degrees. If successful, the drone's tail light will show a green light.

8. Set Return to Home value, creating maps from aerial imagery.

Drone Step 2: Prepare the drone body

1. To install the propeller, attach the propeller with a black ring to the motor with a black dot. Press the impeller onto the mounting plate and rotate it in a locked direction until it locks.

2. Remove the camera lock (Gimbal Lock) before turning on the power every time.

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3. To install the battery, insert the battery into the battery compartment in the direction of the arrow. And should check the battery lock in place

Drone Step 3: Flight planning

One thing to consider before planning a flight Explore the route planning. With the Pix 4D application to set the area of the survey flight. And configured for the survey flight as a Polygon and Grid mission for 2D maps and a high altitude 200-meter. So that the drones can fly and shoot successfully on time in 1 day.

Things to consider before planning an exploration flight are: 1. Type of drone 2 . Memory card. 3 . Prohibited aviation area 4 . Weather condition, wind direction 5. Battery duration 6. Flight altitude 7. Place of takeoff, landing 8. Speed of drone.

Step of flight planning.

Figure 12 Setting parameters in the Pix 4Dmapper application.

1. Set flight routes.

2. Determination of the position, area, altitude of the flight as required.

3. Ensure the flight time is consistent with the drone's flight time and reserve the time to fly to and return to the Take of point.

4. Show a list of recorded flight plans and upload them to the drone at the launch point to instruct the drone to fly according to the designed plan.

Drone Step 4: Aviation photography. Various setting procedures.

1. Open the designed flight plan.

2. Open Project flight settings.

3. Check the shooting settings.

4. Check the speed of flight.

5. Save the settings.

6. Press Start.

7. Confirm the connection.

8. Press Start to confirm the flight according to the mission.

9. The drone will start flying from the launch point, take off to the preset altitude, and then fly to the START point, then start shooting according to the designed settings. Until the end of the mission and will return until the drone release point.

10. Project list, after the drone completes the mission and returns to its launch point, the system will store all photo data on the memory card.

Precautions and solutions to emergency problems during the flight.

1. During the flight, the monitor of the connected device, should be kept up at all times. If there is a broken image signal or remote signal failure, immediately press the RTH button.

2. You should erase the data in the memory card before taking pictures to prevent full data while flying.

3. If the battery is less than 25 percent charged during the flight, the controller should direct the drone to return immediately.

4. The controller should design flight planning and RTH button settings for altitude to ensure that the drone can pass through without obstructions.

5. The RTH altitude setting should be at the same level as the shooting ceiling. In the event of an emergency or direct flight return, the drone will not have to fly below the altitude to that level. Set to save time and energy on the return flight.

3.3.1.2 Database from government agency.

It is open data that can be downloaded from the official website by specifying the area as Sichang Island, Chonburi Province, such as the lithology data. Soil type (ability to drain through the soil), rainfall (precipitation data), and Topographic map of Sichang Island. The closed data, but must be documented for

information request, including high-detailed aerial photographs (taken by survey Royal Thai army aircraft) in 1999,2009,2014. By requesting information support to the Royal Thai Survey Department.

    3.3.2   Step 2: Data processing

        3.3.2.1 Drone image processing:

        1 . Data obtained from Drone DJI Phantom 4, has a system to record coordinates on the image so it is more convenient to use.
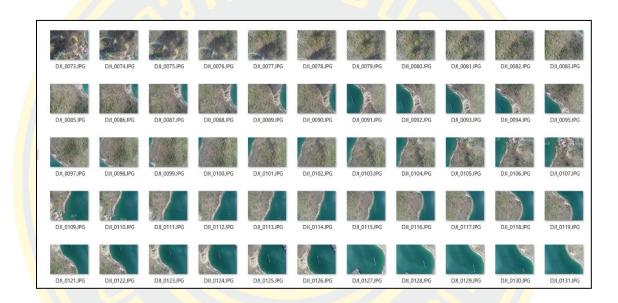
Figure 13 Raw data, 1540 aerial photos from drones(DJI Phantom 4) in Sichang Island.

        2. Start working by opening Pix 4D by clicking the icon Pix 4D or opening from the windows start menu. Enter the name of the Project. , After that press the Browse button on the right to select the desired storage location and press the next button.

        3. The next step is to import the image you want to work on, press the button Add Images and select the image you wish to process. Pix 4D will store the sample information in a folder named Image. Select all the images and press open to import the images. When the import is completed, press the next button.

        4. If the image does not have a coordinate value embedded, the program will tell you that the imported data does not have a coordinate value. Press

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the Ok button to import the coordinate data from the Logfile. Start by defining the UTM WGS84 Zone 47 coordinate system. Press the edit button in the Image Properties window, select Advanced Coordinate Options, and set the coordinate system as needed. Press From List button—select World Geodetic System 1984 in the Datum box and Select 47N in the Coordinate field. When finished, press Ok and press Ok again to return to the Image Properties window.

5. To import the shooting location data by pressing the From File… button, then browse to the file log where the photographed location data is stored in the sample data will be stored in the folder. "Index" file name log.csv, select and check-in file format box, select x, y, z, and press Ok button to import pin value. Press photo location.

6. Check that the imported data is correct or not. After that, press the Next button.

7. Check or select the desired press system in the sample information. Use the UTM WGS84 Z 47N pick system.

8. Select the desired Product Output. For sample information, select 3D Maps and press Finish, completing a new project configuration in the program.

9. The next step is to process the data. 1. Point Cloud, DSM, and Orthophoto by selecting the text field. 2. Point Cloud and Mesh and 3. DSM, Orthomosaic, and Index and cancel. 1. Initial Processing. As shown, then press the start button to process.

Figure 14 Pix 4D-mapper ,step volume and step mosaic.

10. At each step of the process, the program will show the processing results in report format as in Point cloud processing, and when Ortho data processing is complete, there will be a report as directed.

11. The generated data will be in the same folder as the project. Created in step 2, Ortho and DSM data are located in the folder "3_dsm_ortho," where data are GeoTIFF, and Point Cloud data are located in the "2_densification" folder. In the form of * .las.

It can be considered completed in preparing aerial imagery maps from drones in the PIX 4D program.

3.3.2.2 Sichang Island image processing:

We are creating a LULC map of Sichang Islandusing aerial imagery from a drone as a reference. Make a map in the ArcGIS program.

1. Open ArcGIS and select the drone's photo folder in the 3rd section "3_dsm_otho". < 2_mosaic < Koh Sichang.

2. Digitize the polygon of the boundary line of Sichang Island first. For ease of digitalization. Selected no fill color _outline width 0.5 _ outline color red.
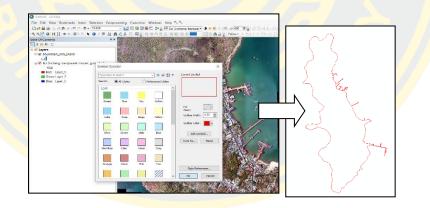

Figure 15 The boundary line of Sichang Island.

3. Use ortho Sichang Island map year 99,09,14 (Get from Royal Thai Survey Department)
Resampling 50 cm. to 1 m., Drone image(2019) resampling 7 cm. to 1 m. and the same way Landsat image too.

4. clip the area by only the entire Sichang area. (obtained the shapefile boundary from the Digitizing drone image)
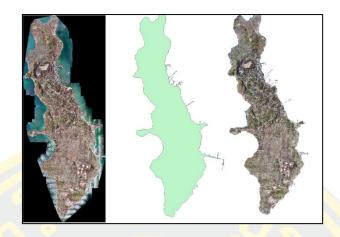
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Figure 16 Sichang Island from drone image, clip shapefile boundary, year 2019.

5. Landsat data: Composite band for Landsat5 band 1-4, Landsat8 band 2-5, and 8. The next step is pan-sharpening the image resolution from 30 meters to 15 meters (especially Landsat8). After that, we resample the image resolution to 1 meter, clip the area only Sichang area. (obtained the shapefile boundary from the Digitizing drone image). For this step, we did not resample 1 meter when we clip the map Sichang Island boundary. There are some errors, and we can't analyze the CA-MACOV model.

6. 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 the CA-MARKOV model.

7. Create a new shapefile by Digitizing, based on drone image. Identify by visual because we can already see resolution 1 meters.

8. Drone can find data for making decisions AHP, DEM calculations, slope calculations, and distance of water sources. NDVI values used data from Landsat 8 satellite image. We can find other information on the government agencies website such as Land Development Department, Meteorological Department.

3.3.2.3 Sichang LULC processing

1. High-resolution image from the drone (resemble 1 meter) as a base to classify (by Digitize) Sichang LULC area into four types which are (1) Vegetation area (2) miscellaneous area (3) urban and build-up (4) water body. Classify by visual

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identification. For my proposal, the file type is img file. We can clearly identify LULC types by visually because we can clearly see the Sichang Island map (resolution 1 meters). Another benefit of using very high-resolution images from the drone is knowing 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.
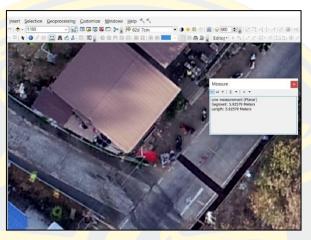
Figure 17 The sharpness of the aerial photos from drone.

       2. Use Ortho RGB aerial photography at Sichang Island (resemble 1 meter) as a base to classify (by Digitize) 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.

Figure 18 Digitize the Sichang area into 4 types.

Table 4 Explanations of the classes and examples of training sites.

Type	Class type	Area (Ground truth)	Aerial image (Drone)	Description
1.	Vegetation area			Crop land, orchard land, grass land, shrub land, garden, perennials, forest.
2.	Miscellaneous area			Bare land, sandbank, excavation site, beach,and abandoned mine.
3.	Urban-build up area			Village, residential, hotel, commercial,industrial area, and transportation infrastructure.
4.	Water body			River, stream,swamp, pond and lake.

3. Step of digitizing Sichang LULC from Drone image or Ortho RGB image.

3.1 Add data (1) Sichang map layers from a drone and Ortho RGB (Royal Thai Survey Department) (2) shapefile boundary from the Digitizing drone image.

3.2 Begin with the digitizing urban and buildup area, which consists of urban areas, buildings, roads, alleys, docks, etc.

1) In ArcGIS program, after select Sichang Island map from drone images as a base map.

2) Left click "catalog icon" > select new folder position > new > shapefile.

3) Select layer Urban build-up > right click > Edit feature > start editing.

4) Left click "create features icon" > left click in create features window > select instruction tool window > polygon.

5) Identify by visual selected building, roads street, piers, dock for to generate many polygons.

Figure 19 Digitization process ,building, street, pears, water body etc.

3.3 Digitizing water body area, which consisting of a reservoir, pond, etc.

3.4 Digitizing Vegetation area, consisting of forest, brake, group of trees, shrubs, etc.

3.5 Union urban and build-up, water, Vegetation 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.

3.6 Shapefile boundary from the Digitizing drone image, use this shapefile erase the union area from 3.5, the output is miscellaneous area.

3.7 Union Vegetation area, miscellaneous, urban and buildup, water area together. Do not allow any overlapping areas.

3.8 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 to vegetation, miscellaneous, urban-build up, water body.

3.9 Converse polygon to raster file.

3.10 Check the sequence of LULC types is as needed. (1=Vegetation, 2 = miscellaneous, 3 = urban buildup, 4 = water body)
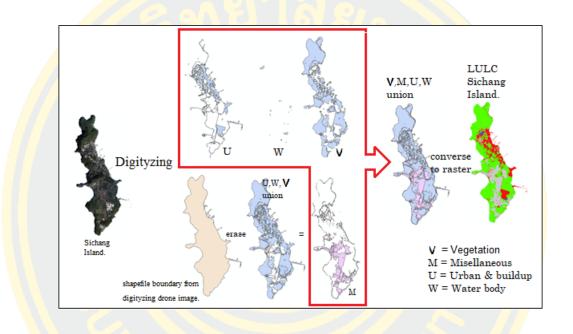
Figure 20 Sequencing process for digitizing area V, M, U, W to generate LULC.

3.11 Make both images (Year 1999,2009,2014,2019) 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) Vegetation 2) Miscellaneous area 3) urban areas 4) Water body and must be arranged in sequence. (every file must be img. file)

3.12 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)

In summary, at this stage, we will obtain the 2 0 1 9 LULC availability data (based on drone images), 2014, 2009, 1999(referring to the Royal Thai Survey Department), and information used to locate the vulnerable areas,

including Landsat8 satellite imagery (NDVI value), Elevation, slope angle, land use, drainage, distance from the reservoir (drone), Lithology and precipitation (government agency website)

3.3.3 Step 3: Data analysis.

3.3.3.1 Assessing the location of natural disaster risky areas.

Arc-GIS.

Potential Surface Analysis (PSA) theory and Procedure Area potential data analysis is an area analysis using linear equations for planning the optimal space utilization by converting the displayed area into a number. (Representation of the figure with numbers) by giving the weight and score values of each factor used in the study (Samo and Anka, 2009) with the following equations.

$$S = \sum W_i \ R_i$$

Where:

- S is the suitability of the area potential.
- W_i is the total weight of factor i.
- R_i is the total score of factor i.

1. Calculate two types of risk value, which are flood and landslide. After getting both types of risky areas map, then combine them together to find complex risky areas again.

2. Risky areas (land slide), there are 7 criteria, the data used include Elevation, slope angle, drainage, land use, Lithology, distance from the reservoir and NDVI value. Data elevation, slope, distance from the reservoir get from Drone data, Lithology, drainage get from government agency website. NDVI value get from Landsat 8 satellite image.

3. Risky areas (flood), there are 7 criteria, the data used include precipitation, slope angle, drainage, land use, Lithology, distance from the reservoir and NDVI value.

4. The weight of each criterion is correlated with the details as in the table. Perform Eigenvector calculations by setting variables based on theories, texts or other theses. The calculations are made on the website AHP Online System - AHP-

OS. https://bpmsg.com/ahp/. In the Decision Matrix to show determining how many times the relationship between each criterion is as important as the other. If the two variables are of equal importance, they are represented by the number 1.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Precipitation (mm)	25.6%	1	13.8%	13.8%
2	Slope angle	19.4%	3	10.0%	10.0%
3	Drainage	25.5%	2	8.8%	8.8%
4	Land use	13.6%	4	6.0%	6.0%
5	Lithology	4.2%	7	0.8%	0.8%
6	Distance from the water source	6.0%	5	1.5%	1.5%
7	NDVI	5.7%	6	2.1%	2.1%

Number of comparisons = 21
Consistency Ratio CR = 5.8%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7
1	1	3.00	1.00	1.00	5.00	5.00	3.00
2	0.33	1	1.00	3.00	5.00	3.00	2.00
3	1.00	1.00	1	3.00	5.00	3.00	7.00
4	1.00	0.33	0.33	1	3.00	3.00	3.00
5	0.20	0.20	0.20	0.33	1	0.50	1.00
6	0.20	0.33	0.33	0.33	2.00	1	1.00
7	0.33	0.50	0.14	0.33	1.00	1.00	1

Principal eigen value = 7.464
Eigenvector solution: 6 iterations, delta = 1.4E-9

Figure 21 Eigenvector (priorities) and decision matrix (flood)

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Elevation	13.1%	3	3.0%	3.0%
2	Slope angle	20.5%	2	8.9%	8.9%
3	Drainage	32.0%	1	14.0%	14.0%
4	Land use	13.1%	3	3.0%	3.0%
5	Lithology	4.7%	6	2.5%	2.5%
6	Distance from the water source	12.0%	5	5.4%	5.4%
7	NDVI	4.5%	7	0.9%	0.9%

Number of comparisons = 21
Consistency Ratio CR = 5.1%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7
1	1	1.00	0.33	1.00	3.00	1.00	3.00
2	1.00	1	1.00	1.00	5.00	3.00	3.00
3	3.00	1.00	1	3.00	3.00	5.00	7.00
4	1.00	1.00	0.33	1	3.00	1.00	3.00
5	0.33	0.20	0.33	0.33	1	0.20	1.00
6	1.00	0.33	0.20	1.00	5.00	1	3.00
7	0.33	0.33	0.14	0.33	1.00	0.33	1

Principal eigen value = 7.407
Eigenvector solution: 5 iterations, delta = 1.9E-8

Figure 22 Eigenvector (priorities) and decision matrix (land slide).

5. Prove C.R. value < 0.1 Therefore, the consistency of comparison is within acceptable values. (Flood = 0.058, Land slide = 0.051)

6. Take the boundary of Sichang Island (obtained from the Digitize image from the drone) to clip with all data layers, so every layer is the same size.

7. Make all seven layers of data into raster data and assign output values 1,2,3 (Risk level height = 5, medium = 3, low = 1). According to the table, in this step, we will see the color difference shown in each data layer. After that, reclassify to only three types. The Raster format is calculated by calculating each factor in the Raster format and then calculating each element to find the appropriate area. After that, substituting values from formulas.

$$S = (W_1R_1)+..+(W_iR_i)$$

Where:

- S is the suitability of the area potential.
- W_i is the total weight of factor i.
- R_i is the total score of factor i.

Table 5 Explanation of data, criteria, value and risk map.

criteria	Data	Value		map
		Flood	**Land slide**	
Elevation	< 67 meters	-	5	
	67 - 135 meters	-	3	
	> 135 meters	-	1	
precipitation	< 1302.56mm	1	-	
	1302.56 -1499.42 mm	3	-	
	> 1499.42 mm	5	-	

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Slope angle	< 18%	5	1	
	18 – 35%	3	3	
	> 35%	1	5	
Drainage	well drained	1	5	
	moderate drainage	3	3	
	bad drain	5	1	
LULC	Urban area	5	5	
	Miscellaneous area	3	3	
	Vegetation area	1	1	
Distance from the water source	< 500 meters	5	5	
	500 – 1,000 meters	3	3	
	> 1,000 meters	1	1	
Geological data	Triassic	1	1	
	Carboniferous-Permian	3	3	
NDVI	-1 – 0.2	5	5	
	0.2 – 0.4	3	3	
	0.4 – 1	1	1	

8. 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

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

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

Complex risky areas = 0.5(landslide prone areas) + 0.5(flood-prone areas).

9. After getting the risk map (flood and land slide), bring both of them to the combined risky area map. By using 1 to 1 weighting. Use the map algebra function in Arc GIS again. In the final step, you will get a combined risk map.
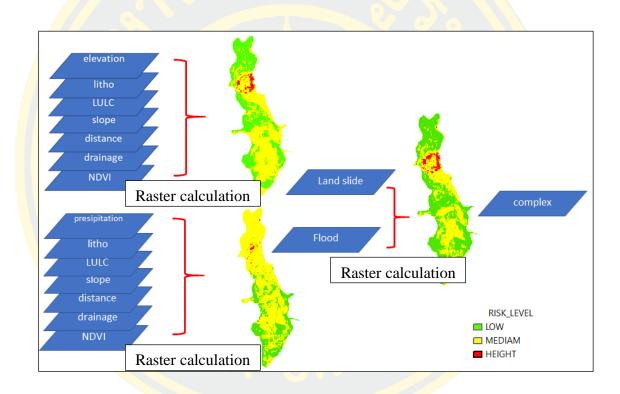

Figure 23 The process of creating risky area map, land slide, flood, complex.

3.3.3.2 Predict LULC next 5, 10, 20 years

IDRISI: MARKOV Chain step. Example predict Years 2029 (2009 compere 2019)

1. Use the IDRISI program to calculate future LULC area changes. The first step is to create a new folder, separated into working folders.

2. Converse .img file to .rst file Import image by Geotiff/tiff (depend on ArcGIS version) or .img file. This proposal is .img file.

3. Open new .rst file that got from (2.) in ArcGIS for check value, for 2 images (2009, 2019) must be in equal class and same area and same resolution.

4. Reclassify both map at 4 types again. (in ArcGIS)

5. Set the Label value to an integer only. (in ArcGIS)

6. Run MARKOV Chain step. Selected a base image as 2009 (Ortho RGB aerial photography) compared to 2019 (image from the drone)

7. Defines the gap of both years, 10 years and set the predicted year as the future for the next 10 years.

Figure 24 Run MARKOV Chain, set value.

8. Do not select maps from browsing. The maps that we use must only come from the folder we created, therwise the program will not calculate, all operations will be in the same folder.

9. When we finished this MARKOV step. We get 3 thing that are conditional probability map, transition area matrix, transition probability matrix.

Class 1 2 3 4 means Vegetation(V), Miscellaneous(M), Urban and Built-up(U), Water body(W) chronologically number. This table describes changes in values in the form of percentage ratios, from what has changed to what, what is still the same, and would

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like to give an example in the red rectangle as follows: V became to U =7.42%, M became to U =7.90%, V still be V =89.41%, W became to V =27.87%.

Figure 25 MARKOV Chain, transition probability matrix.
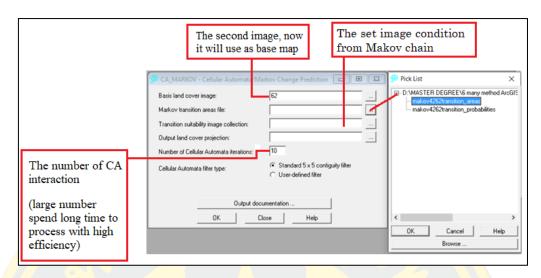
10. IDRISI: CA-MARKOV step.

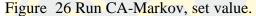10.1 Run CA-Markov Model at Modeling > Environmenttal/Simulation Models > Time Series > CA_MARKOV.

10.2 Selected a base map 2 0 1 9 (High-resolution image from the drone) compared 2 part. The transition area from Markov chain, conditional probability map. (get from 4.9)

10.3 Select cellular automata filter type standard 5x5 contiguity filter.

10.4 Time used in calculations depends on the number of cellular automata interaction.

Figure 26 Run CA-Markov, set value.

10.5 Get the LULC map of Sichang Island in the future for the next 10 years (dividing land use into 4 types)

11. Predict the area in the future for the next 5,20 years. Work procedures same predict 10 years before. Next 5 years use map in years 2014, 2019 and Next 20 years use map 1999, 2019.

12. Calculate usable space over the next 5,10,20 years as before, but change the base map to a satellite imagery map (Landsat5, Landsat8) to compare the differences with the first method. (Aerial photos from Drone)

13. Check the accuracy of the prediction map (CA-MARKOV). Use the map from year 1999 compared with 2009 to predict the 2019 map. The results are compared with the actual map data obtained from drone. I show some the example follow Figure 27.

- The Drone and Ortho RGB aerial photo, result accuracy is 93.61%

- The satellite images Landsat, result accuracy is 62.68% (before use raster calculation in ArcGIS program, must resample resolution both maps to 1 meter) By comparing the two options, the researcher can see that the very high-resolution drone imaging method results are 30.93% more accurate because the satellite images are significantly lower in resolution. Land Sat satellites have a resolution of 30 meters, but images from the drone have a resolution 7 cm. Rough resolution to high resolution is almost impossible, unlike high-resolution images converting them into low-resolution images like this one, and we can identify the object as well.
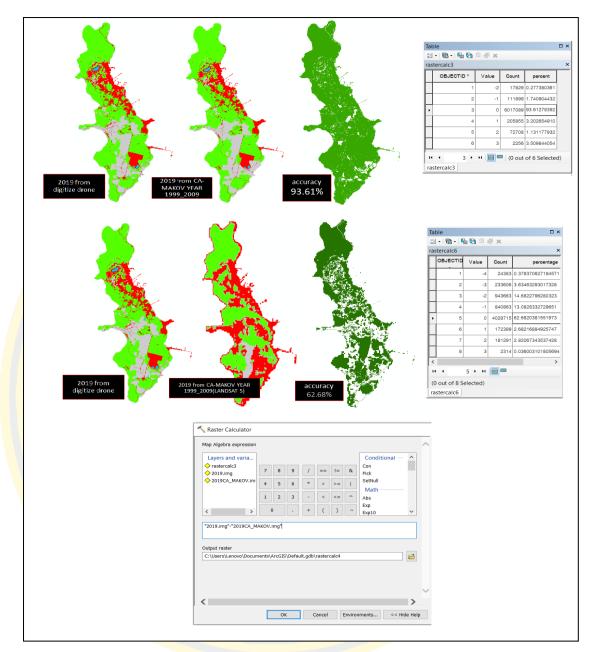
Figure 27 Accuracy map CA_MARKOV, between Drone images and satellite image.

CHAPTER 4

RESULT AND DISCUSSION

After the researcher has planned the research and gathered the theory and knowledge required in Chapter 2, followed the research procedure in Chapter 3 to achieve the desired objective results with the following results.

Objective 1 results: can be generated based on seven layers of highly detailed photographs from the Drone DJI-Phantom4, using the generated data will be implicated in this research.

Objective 2 Results: After determining the Criteria variable by creating a flood risk map, there were 7 variables, creating a soil risk map with 7 variables, when both types of risk maps were obtained and computed into a map. Therefore, it allows knowing the location on Sichang Island that the area has the highest risk.

Objective 3 results: Calculate the future LULC for the next 5 years, 10 years and the next 20 years (these figures correlate with the EEC Specific Economic area development plan determined by the Thai government, Sichang Island is in the EEC development zone.) Perform classified areas into 4 types: Vegetation area, Urban build-up area, miscellaneous area, water body area.

4.1 Objective 1 result: Obtain 7 FGDS layers of Sichang Island.

(1) Map of Sichang Island (drone image resolution 1 m.) (2) Boundary. (3) Slope (4) LULC (Vegetation area, Urban-build up, miscellaneous, water body a) (5) Elevation (6) Contour line (7) Road, street

4.2 Objective 2 results: To know the risky areas on Sichang Island.

- Flood risky areas It has a low-risky area with a total area of 2.608334 square kilometers, medium-risk with a total area of 3.518102 square kilometers, high risky area with a total area of 0.137711 square kilometers, as shown in the figure 28.

- Landslide risky area It has a low-risky area with a total area of 1.701148square kilometers, medium-risk with a total area of 4.521207 square

kilometers, high risk with a total area of 0.041792 square kilometers, shown in the figure 29.

　　　　- Complex risk maps (Integrated landslide and flood risk) have a low-risky area with a total area of 3.436116 square kilometers. Medium risk with a total area of 2.648528 square kilometers, high risk with a total area of 0.179503 square kilometers, shown in the figure 30.
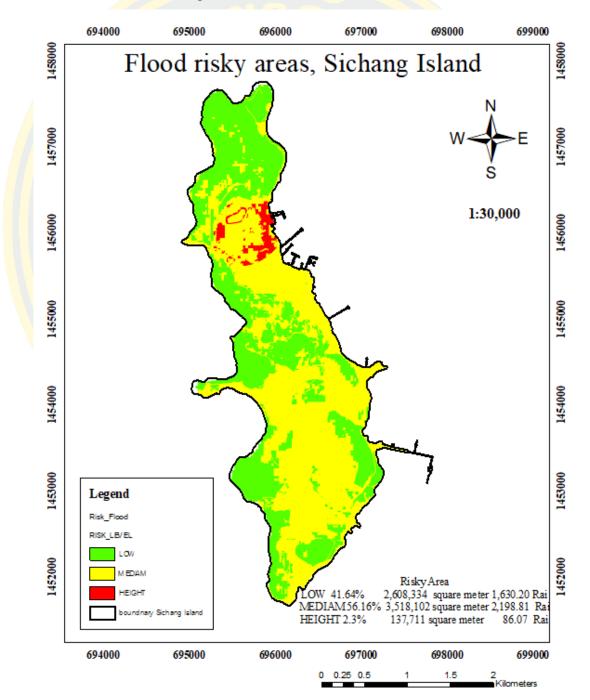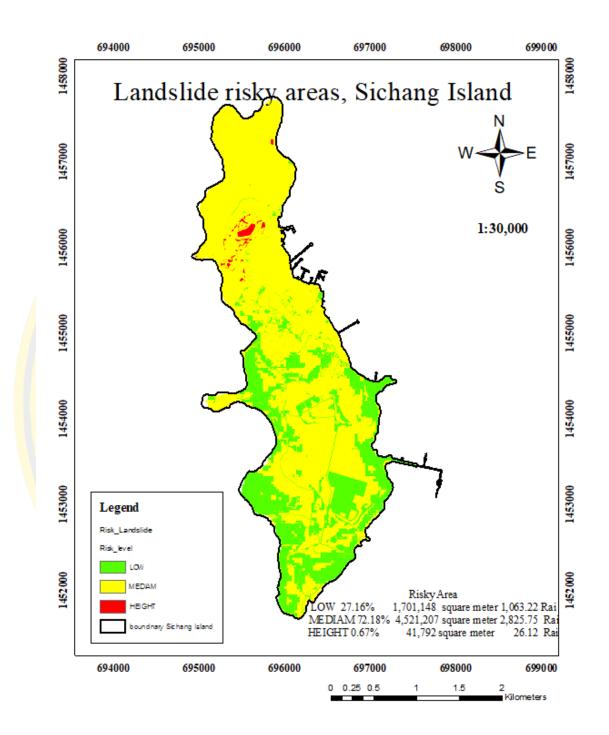

Figure 28 Flood risky area map.

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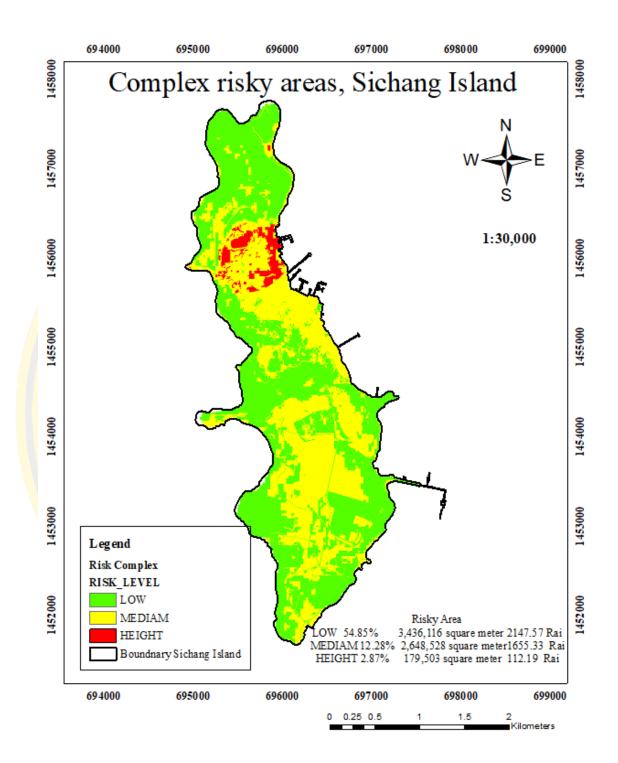Figure 29 Land slide risky area map.

Figure 30 Complex risky area map.

4.3 Objective 3. Results: LULC area for the next 5,10,20 years on Sichang Island

Sichang Island LULC analysis by CA-MARKOV model (Between years 1999, 2009, 2014, 2019). Land use in the past and present (Land Use & Land Cover) in the area of Sichang Island by applying Geographic Information Science (GI Science).

4.3.1   Land Use & Land Cover in Sichang Island area

Historical land use data of Sichang Island, using a visual interpretation using a 50 cm very high-resolution aerial photographic image (Royal Thai Survey Department) taken on December 26. 1999, as shown in Figure 31, the land use classification of Sichang Island was divided into 4 categories as follows:

- Vegetation, an area of 3.8173 square kilometers, representing 59.41 percent of the total area.

- Miscellaneous areas, grasslands, beaches, an area of 1.6099 square kilometers, representing 25.05 percent of the total area.

- Building area or community area of 0.9571 square kilometers, representing 14.89 percent of the total area.

- The area of the water source area of 0.0415 square kilometers, or 0.65 percent of the total area.

Table 6 Land use and Land cover of Sichang Island, years 1999.

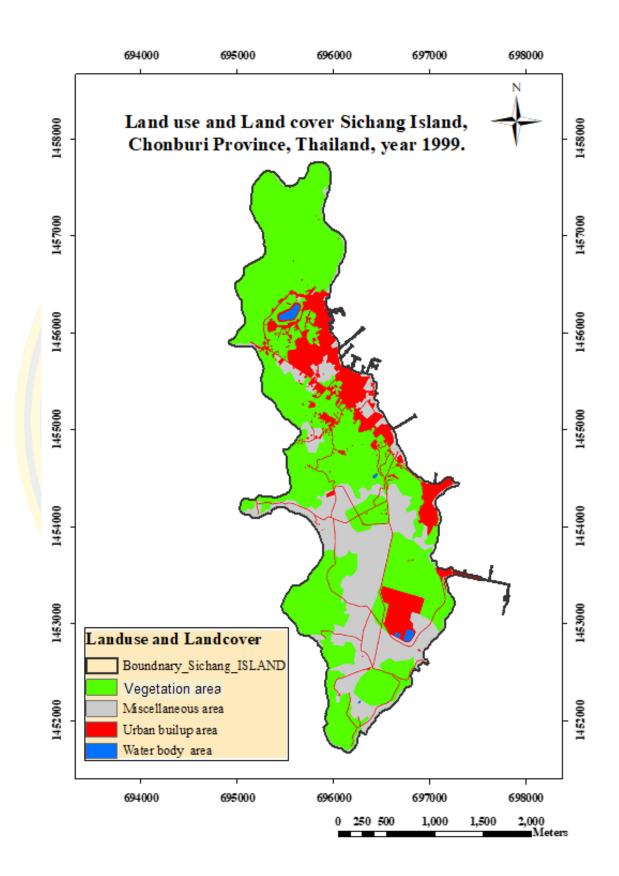| Type	Area (m^2)	Area (Km^2)	Percentage of total area
Vegetation	3817383	3.817383	59.4050
Miscellaneous	1609936	1.609936	25.0533
Urban-build up	957122	0.957122	14.8945
Water body	41590	0.04159	0.6472
Total	6426031	6.426031	100

Figure 31 LULC Sichang Island map years 1999.

Historical land use data of Sichang Island, using a visual interpretation using a 50 cm very high-resolution aerial photographic image (Royal Thai Survey Department) taken in years 2009, the land use classification of Sichang Island was divided into 4 categories as follows:

- Vegetation, an area of 3.9257 square kilometers, representing 61.05 percent of the total area.

- Miscellaneous areas, grasslands, beaches, an area of 1.49 square kilometers, representing 23.21 percent of the total area.

- Building area or community area of 0.9791 square kilometers, representing 15.23 percent.

- The area of the water area of 0.0334 square kilometers, or 0.52 percent of the total area.

Table 7 Land use and Land cover of Sichang Island, years 2009.

Type	Area (m^2)	Area (Km^2)	Percentage of total area
Vegetation area	3925722	3.925722	59.4050
Miscellaneous area	1492403	1.492403	25.0533
Urban-build up area	979189	0.979189	14.8945
Water body area	33416	0.033416	0.6472
Total	6426031	6.426031	100
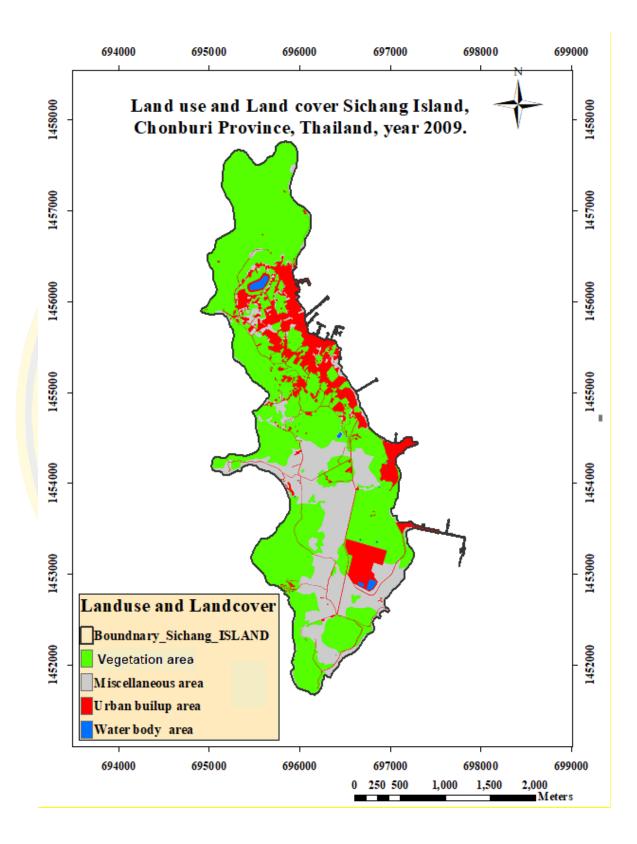
Figure 32 LULC Sichang Island map years 2009.

2014 Historical land use data of Sichang Island, using a visual interpretation using a 50 cm very high-resolution aerial photographic image (Royal Thai Survey Department) taken in years 2014, the land use classification of Sichang Island was divided into 4 categories.

- Vegetation, an area of 3.9477 km^2, representing 61.39 percent of the total area.

- Miscellaneous areas, grasslands, beaches, an area of 1.4561 km^2, representing 22.64 %

- Building area or community area of 0.9906 km^2, representing 15.40 % of the total area.

- The area of the water source area of 0.0362 km^2, or 0.56 % of the total area.

Table 8 Land use and Land cover of Sichang Island, years 2014.

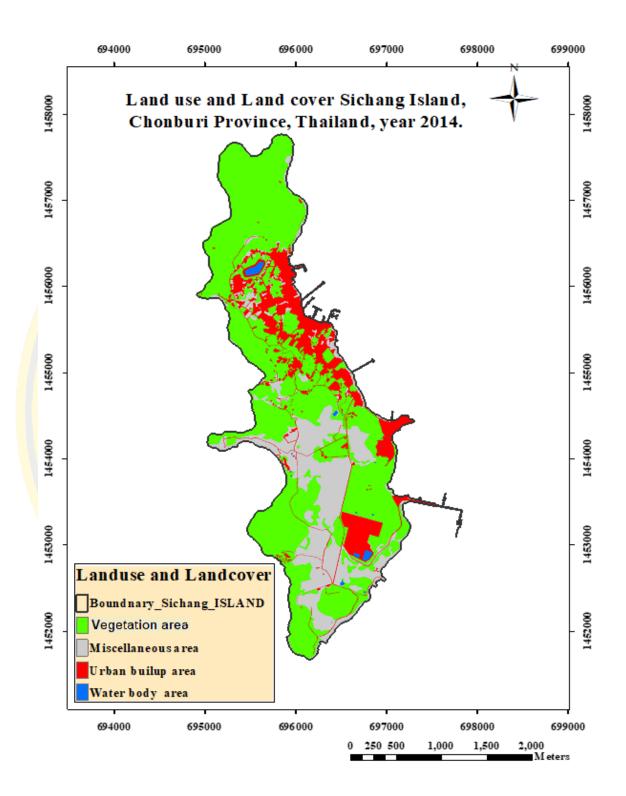| Type	Area (m^2)	Area (Km^2)	Percentage of total area
Vegetation area	3,947,754	3.947754	61.38889364
Miscellaneous area	1,456,168	1.456168	22.6438989
Urban-build up area	990,602	0.990602	15.40419206
Water body area	36,206	0.036206	0.563015396
Total	6,430,730	6.43073	100

Figure 33 LULC Sichang Island map years 2014.

2019 Historical land use data of Sichang Island, using a visual interpretation using a 7 cm very high-resolution aerial photographic image by UAV or drone, flying drone on 2019/09/01, the land use classification of Sichang Islandwas divided into 4 categories.

- Vegetation, an area of 3.9049 km^2, representing 60.75 percent.

- Miscellaneous areas, grasslands, beaches, an area of 1.4066 km^2, representing 21.88 %

- Building area or community area of 1.07939 km^2, representing 16.79 %

- The area of the water source area of 0.0367 km^2, representing 0.57 %

Table 9 Land use and Land cover of Sichang Island, years 2019.

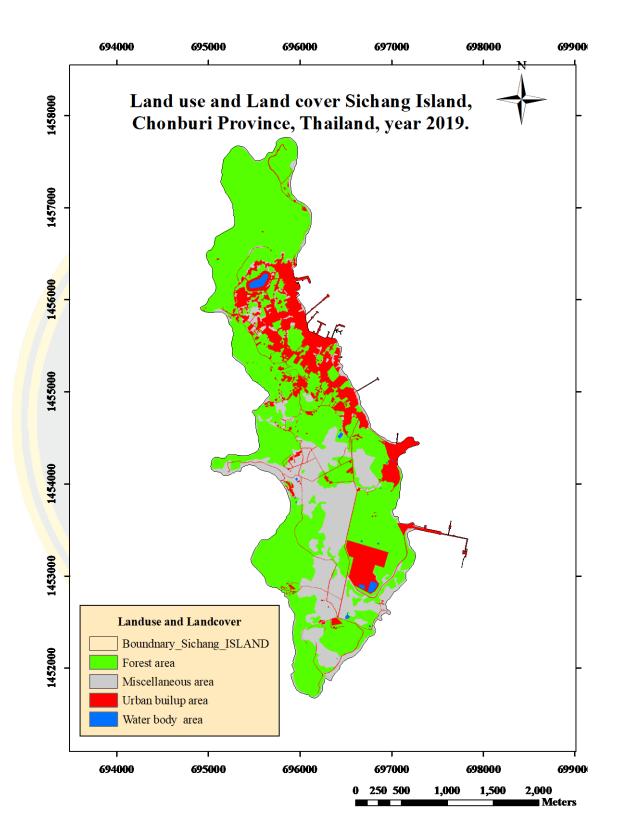| Type	Area (m2)	Area (Km2)	Percentage of total area
Vegetation area	3,904,934	3.904934	60.75225791
Miscellaneous area	1,406,674	1.406674	21.88478003
Urban-build up area	1,079,343	1.079343	16.79222346
Water body area	36,685	0.036685	0.570738604
Total	6,427,636	6.427636	100

Figure 34 LULC Sichang Island map years 2019.

4.3.2 Prediction LULC for the next **5** years in the Sichang Island area.
From the land use classification of Sichang Island, 2014 map and 2019 map, the CA-Markov model as follows:

Sichang Island LULC Forecast 2024. The results from the forecast can be classified into four categories of Sichang Island land use as follows:

- Vegetation , an area of 3.86 square kilometers, or 60.08 percent of the total area.

- Miscellaneous areas, grasslands, beaches, abandoned mine an area of 1.36 square kilometers, accounting for 21.14 percent of the total area

- The area of buildings or communities with an area of 1.17 km^2, or 18.20 percent of the total area.

- Water source area, area size 0.037 square kilometers, accounting for 0.57 percent.

Total area of classification, size 6.43 square kilometers, as shown in the table 11.

Table 10 Land use and Land cover of Sichang Island, years 2024.

Type	Area (m^2)	Area (Km^2)	Percentage of total area
Vegetation area	3,862,174	3.862174	60.08741687
Miscellaneous area	1,359,104	1.359104	21.14483931
Urban-build up area	1,169,601	1.169601	18.19656568
Water body area	36,713	0.036713	0.571178133
Total	6,427,592	6.427592	100

Forecast of changes in LULC of Sichang Island during 2014 and 2019, the results from the forecast can classify modifications to the land use type of Sichang Island as follows:

- Vegetation has an area of 3.8621 square kilometers, decreased from the year 2019 amount 42,839 square meters, changing to urban-build up area 63,804 square meters, water bodies 101square meters

- Miscellaneous areas, grasslands, beaches, an area of 1.3622 square kilometers, increased from the year 2019 amount 44,443 square meters, changing to

Vegetation 21,066 square meter, urban-build up area 26,505 square meter, water body area 243square meter.

      - Building or community area has an area of 1.1661square kilometers, increased from the year 2019 number of 86,800 square meters with change from Vegetation area 63,804 square meters, miscellaneous area 26,505 square meters.

      - Water body area has an area of 0.0372 square kilometers, increasing from year 2019 amount 482 square meters, with change from Vegetation area 101 square meters , miscellaneous area 243 square meters, urban-build up area 138 square meter. Total area for classification, size 6.4276 km^2 as shown in the table 12 and the figure 36.

Table 11 LULC change in Sichang Island between the year 2019 and 2024 (m^2)

2019	2024				
	V	M	U	W	Total
Vegetation	3,841,008	0	63,804	101	3,904,913
Miscellaneous	21,066	1,358,860	26,505	243	1,406,674
Urban-build up	0	3,371	1,075,833	138	1,079,342
Water body	0	0	0	36,685	36,685
Total	3,862,074	1,362,231	1,166,142	37,167	6,427,614

      The researcher used a computer (CPU: Intel (R) Core (TM) i7-9750H CPU @ 2.60GHz 2.59 GHz, RAM 24 GB) to run the program in the calculation part (using a drone image as a base), a Markov chain procedure used approximately 1 minute, the CA-Markov process takes about 4-5 hours. Running the computation part (using Landsat 5,8 satellite image as the base), the Markov chain step takes about 20 seconds. The CA Markov procedure takes about 3-4 hours. In the calculation, both methods choose to put the number 50 in the box "Number of Cellular Automata iterations.
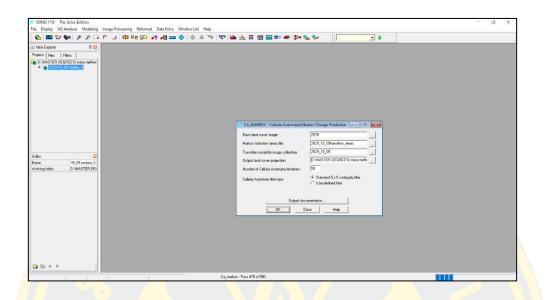
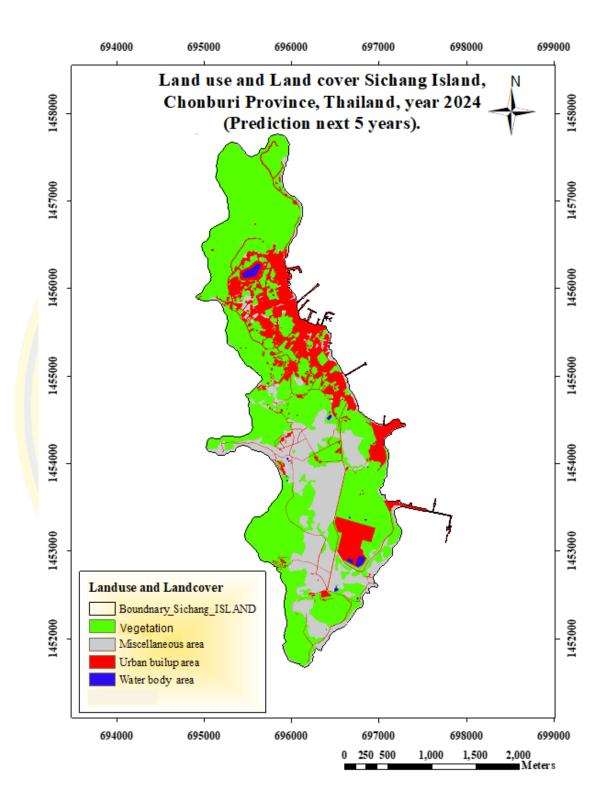Figure 35 CA MARKOV-Cellular Automata/Markov change Prediction.

Figure 36 LULC Sichang Island map years 2024.

4.3.3 Prediction LULC for the next 10 years in the Sichang Island area

For years 2029 LULC classification of Sichang Island, 2009 map, and 2019 map, the CA-Markov model was found as follows:

- Vegetation, an area of 3.8783 square kilometers, or 60.40 percent of the total area.

- Miscellaneous areas, grasslands, beaches, an area of 1.3292 square kilometers, or 20.70 percent of the total area.

- The area of buildings or communities with an area of 1.1767 square kilometers, or 18.32 percent of the total area.

- Water source area, area size 0.0367 square kilometers, accounting for 0.57 percent.

The total area of classification, size 6.421 square kilometers, as shown in Table 13.

Table 12 Land use and Land cover of Sichang Island, years 2029.

Type	Area (m^2)	Area (km^2)	Percentage of total area
Vegetation area	3,880,354	3.880354	60.37047599
Miscellaneous area	1,330,274	1.330274	20.69637837
Urban-build up area	1,180,242	1.180242	18.36218328
Water body area	36,699	0.036699	0.570962365
Total	6,427,592	6.427592	100

Forecast of changes in land use of Sichang Island during 2009 and in 2019, the results from the forecast can classify changes to the land use type of Sichang Island as follows:

- Vegetation has an area of 3.8783 square kilometers, area decreased from the year 2019 is 26,634 square meters, changing to miscellaneous area 64,507 square meters urban-build up area 67,725 square meters, water body area 2,056 square meters

- Miscellaneous areas, grasslands, beaches, an area of 1.3292 square kilometers, decreased from the year 2019 amount 77,421 square meters, changing to

Vegetation 107,654 square meter, urban-build up area 33,262 square meter, water body area 1,013 square meter.

       - Building or community area has an area of 1.1767 square kilometers, increased from year 2 0 1 9 number of 100,846 square meters with change from Vegetation area 67,725 square meters, miscellaneous area 33,262 square meters.

       - Water area has an area of 0.0398 square kilometers, increasing from year 2 0 1 9 amount 3,209 square meters, change from Vegetation area 2,056 square meters, miscellaneous area 1,013 square meters, urban-build up area 140 square meters.

Total area for classification, size 6.4242 square kilometers as shown in the table 14 and the figure 37.

Table 13 Forecast of changes in LULC in Sichang Island between the year 2019 and the year 2029 (m^2)

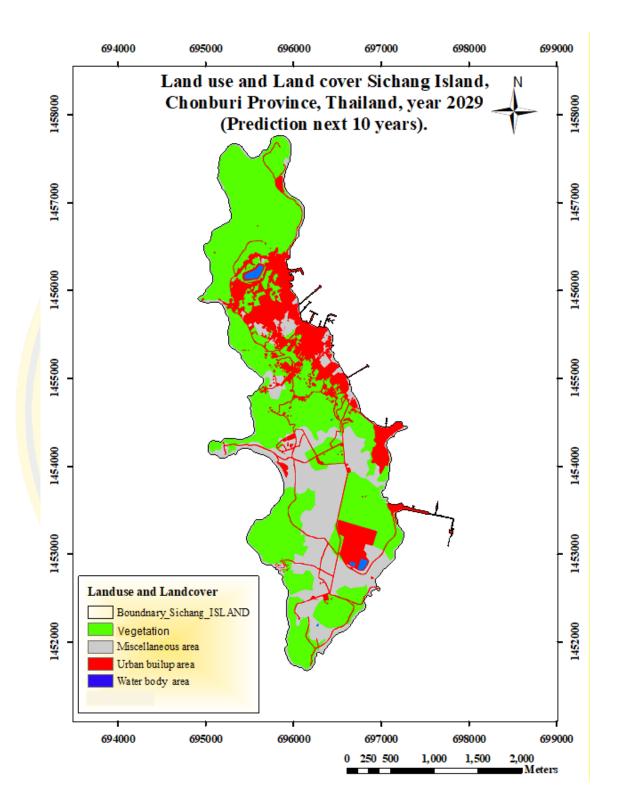| | 2029 | | | | |
2019	V	M	U	W	Total
Vegetation	3,770,646	64507	67,725	2,056	3,904,934
Miscellaneous	107,654	1,264,744	33,262	1,013	1,406,673
Urban-build	0	1	1,075,793	140	1,075,934
Water body	0	0	0	36,685	36,685
Total	3,878,300	1,329,252	1,176,780	39,894	6,424,226

Figure 37 LULC Sichang Island map years 2029.

4.3.4   Prediction LULC for the next 20 years in the Sichang Island area

        2039 Prediction LULC for the next 20 years in the Sichang Island area, from the LULC classification of Sichang Island, 1999 map and 2019 map, the CA-Markov model was found as follows:

        - Vegetation area of 3.7699 square kilometers, or 58.66 percent of the total area.

        - Miscellaneous areas, grasslands, beaches, an area of 1.2518 square kilometers, or 19.48 percent of the total area

        - The area of buildings or communities with an area of 1.3759 square kilometers, or 21.41 percent of the total area.

        - Water source area, area size 0.0284 square kilometers, accounting for 0.44 percent of the total area

Total area of classification, size 6.4262 square kilometers, shown in the table 15 and figure 38.

Table 14 Land use and Land cover of Sichang Island, years 2039.

Type	Area (m^2)	Area (Km^2)	Percentage of total area
Vegetation area	3,769,946	3.769946	58.66567447
Miscellaneous area	1,251,819	1.251819	19.4800684
Urban-build up area	1,375,889	1.375889	21.41077251
Water body area	28,499	0.028499	0.443484617
Total	6,426,153	6.426153	100

        Forecast of changes in land use of Sichang Island during 1999 and in 2019, the results from the forecast can classify changes to the land use type of Sichang Island as follows:

        - Vegetation   has an area of 3.7699 square kilometers, area decreased from the year 2019 is 133,504 square meters, changing from miscellaneous area 381,256 square meters, urban-build up area 62,300 square meters, water body area 75 square meters

- Miscellaneous areas, grasslands, beaches, an area of 1.2518 square kilometers, decreased from the year 2019 amount 154,855 square meters, changing from Vegetation 284,973 square meter, urban-buil up area 52,017 square meter, water body area 2,908 square meter.

- Building or community area has an area of 1.3759 square kilometers, increased from year 2019 number of 296,546 square meters, changing from Vegetation 289,471 square meter, miscellaneous area 111,167 square meters, water body area 10,255 square meter.

- Water area has an area of 0.0285 square kilometers, decreasing from year 2 0 1 9 amount 8,187 square meters, changing from Vegetation 2,691 square meter, miscellaneous area 2,330 square meters. Total area for classification, size 6.4242 square kilometers as shown in the table 16 and figure 38.

Table 15 Forecast of changes in land use in Sichang Island between the year 2019 and the year 2039 (m^2)

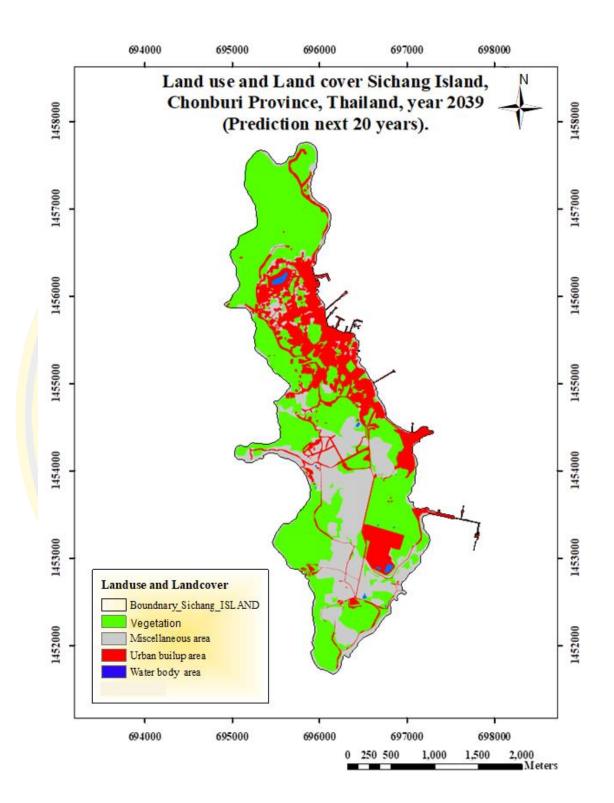| 2019	2039				
	V	M	U	W	Total
Vegetation	3,326,315	284973	289,471	2,691	3,903,450
Miscellaneous	381,256	911,921	111,167	2,330	1,406,674
Urban-build	62300	52,017	965,026	0	1,079,343
Water body	75	2908	10225	23,478	36,686
Total	3,769,946	1,251,819	1,375,889	28,499	6,426,153

Figure 38 LULC Sichang Island map years 2039.

CHAPTER 5
CONCLUSIONS

In this study, aerial imagery from a drone (flying at an altitude of 200 meters above ground level), was processed in the Pix 4D Mapper program, resulting in a highly detailed photographic map of Sichang Island, Chonburi Province, Thailand. After that, this map was used as the base for this thesis with the intention of studying flood and landslide risky areas. After that, both types of risks were used to calculate the complex risky areas. And another case study is the prediction of the island's future LULC area, which is intended to correlate with the Thai government's Eastern Economic Corridor (EEC), with a focus on mainland development. Mostly The researcher noticed the potential within Sichang Island, which is already in the EEC area and has the ability to develop spatial, the government has the opportunity to invest and develop. Moreover, Sichang Island has the potential to develop advantages to other islands, for example, the distance near the capital city (Bangkok) takes about 1 hour, and there is a deep sea port with a large oil terminal on the southern island area. In addition, it is also a natural and religious tourist attraction.
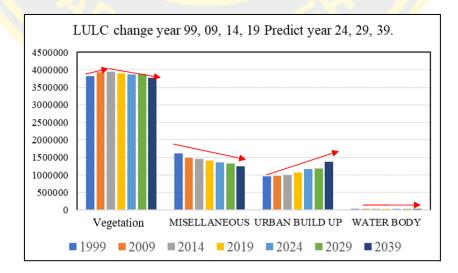
Economic development plan of The EEC will focus on spatial capacity development and select specific areas where development can be expected. The researcher then researched the risky areas on Sichang Island in 2019 (the year of thesis commencement) and predicted the future LULC area by using the CA-Markov Model to calculate the results by referring to the distance between the intervals in relation to the strategic plan. The nation of Thailand is 5 years, 10 years and 20 years. The researcher sees that it is very likely that the results of this research will benefit Sichang Island and the government's EEC economic development plan.
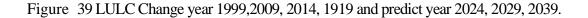
The results of the study were able to serve three objectives: the first objective was to generate the FGDS data layer based on aerial images from drones, which were more detailed and high resolution than those of Thai government agencies (old data). There are 7 layers including (1) Map of Sichang Island (drone image resolution 1 m.) (2) Boundary. (3) Slope (4) LULC (Vegetation area, Urban-build up, miscellaneous, water body a) (5) Elevation (6) Contour line (7) street, Objective 2: To

know the risky area on Sichang Island.There are two communities in the risky area. Ban Tha Thewa Wong and Ban Saphan Khu community, with a total population of 595 people (in the civil registration system). The government agencies of Sichang Island District should have a plan for the future in order to reduce or prevent it from occurring due to disastrous impacts, for Objective 3: We can predict the future LULC for the next 5 years, 10 years, 20 years. Details according to the table 17, as shown in the Figure 39.

Table 16 LULC area size in years 1999, 2009, 2014, 2019 and forecast area in year 2024, 2029, 2039. (square meters and Rai)

Drone image year 2019, Otho RGB aerial photo year 99,09,14							
	Area_square meter				Area_Rai		
YEAR	V	M	U	W	V	M	U	W
1999	3817383	1609936	957122	41590	2385.86	1006.21	598.20	25.99
2009	3925722	1492403	979189	33416	2453.58	932.75	611.99	20.89
2014	3947754	1456168	990602	36206	2467.35	910.11	619.13	22.63
2019	3904934	1406674	1079343	36685	2440.58	879.17	674.59	22.93
2024	3862174	1359104	1169601	36713	2413.86	849.44	731.00	22.95
2029	3880354	1330274	1180242	36713	2425.22	831.42	737.65	22.95
2039	3769946	1251819	1375889	36699	2356.22	782.39	859.93	22.94

Figure 39 LULC Change year 1999,2009, 2014, 1919 and predict year 2024, 2029, 2039.

Predicting future utilization areas, there is an urban expansion which is consistent with thesis or other research results, for example Teerawate Limgomonvilas (2014), where he discusses the expansion of urban areas in the Lam Takong River Basin Study Area. Using images from the historical Landsat satellite to compare the changes in the area and the result is an increase in urban areas.

Sichang Island has the same amount of area (Only the land on the island), no expansion or reduction of the land, just a change of position 4 types (Vegetation area, Miscellaneous area, Urban-build up area, water body area). Many Vegetation areas in years 1999-2014, the value has increased, but after that is gradually declining, the miscellaneous area continued to decline, urban areas and buildings continued to increase, stable water body area rarely changed, in consequence of prosperity and expansion of the community, has more buildings, more population, and more tourists. Tourists have one-day trips (due to the travel time from Bangkok only about 90 minutes), or that tourists would like to stay overnight on the island, they can do. There is also an industrial plant area, a deep seaport, and many tank farms for large cargo ships on the southern part, which in the future could be developed into a larger, modern place to serve as a refueling point for container ships. Waiting point for large cargo ships waiting to pass through a pilot station in the Chao Phraya River to the Bangkok port or to Laem Chabang port on the other side of the mainland island. With the expansion of buildings and urban society like this, the next thing is the expansion of the population, so there must be more surveys of habitats and water sources, as well as the amount of waste that will increase with the number population which needs to have a development plan to determine methods and areas for waste disposal in the future.

The researcher would like to mention that data acquisition from satellite imagery, with very high resolution such as 1-meter level, would be very costly. Suppose we used satellite images that can be downloaded from free sources such as sentinel2A or Landsat. In that case, it is not suitable for this research, that is we want to predict LULC areas in the next 5, 10, and 20 years, which means we have to prepare some maps from a satellite image of Sichang Island in the past 20 years 10 years and 5 years ago (1999,2009,2014) that represented the sentinel 2A was unable to support it, as it just entered orbit in the year 2015 so left only the Landsat 5 satellite

and Landsat 8 only. Researchers used data from Landsat5 satellites in 1999,2009, and Landsat 8 in years 2014, 2019 using the same study area, Sichang Island, Chonburi Province, Thailand. But with a restoration at 30 m. (Landsat 8 panchromatic at 15 m.), It is still very difficult to classifieds the LULC area because Sichang Island has a total area of about 6 square kilometers. After comparing, classify using aerial photos from drones as a base, the results in many errors. And when taking the resulting map image that has a lot of mistakes and then calculated in the CA-MARKOV model, there will be even more errors. The researcher himself solved this problem by seeking support from the Royal Thai Survey Department, which was obtained from using a survey plane and photographed the Sichang Island area in the years 1999, 2009, 2014 with three intervals and a resolution of 50 centimeters. It is sufficient to classify the LULC area visually. Still, The Royal Thai Survey Department has budget constraints and cannot fly airborne as frequently as the use of the aircraft has a very high budget. Royal Thai Survey Department cannot do it every year. In the opinion of future researchers, these problems could be mitigated if government agencies that fly drones to collect aerial images collect data at a particular agency over time and we need it. Historical data will be easier to access and retrieve that data can be used to perform various calculations.
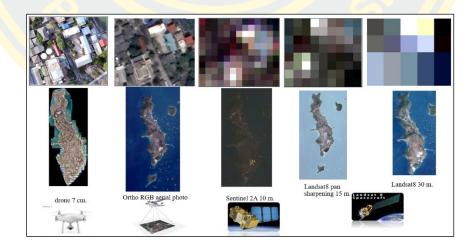

Figure 40 Comparison of resolution between Drone images, Ortho RGB aerial photo, Sentinel 2A, Landsat 8 satellite image.

From this research, the researchers saw another benefit and suitability of the drone: the area study is not a very large area, Sichang Island, with an area of about 6.5 square kilometers, is more suitable to use drone imagery than satellite imagery.

The researchers wanted to point out another benefit of drones LULC's classification accuracy by conducting this research. Because after getting an aerial map from the drone (through the program Pix 4D-mapper), can see details as sharp as 7 centimeters, easier to digitize into a polygon, and classify land use with higher accuracy than computerized. Calculate other benefits are better than satellite imagery, such as reducing the constraints of orbiting satellites or days with poor visibility, such as cloudy or rainy, that drones can already fly under the clouds. Etc. Nowadays, UAVs or Drone have increasingly played a role in Thai people's daily lives, such as supporting military security, agriculture, photography, education, environmental conservation, and large-scale construction surveys. The cost of the drone is also lower; on the contrary, the drone's performance is increased, the functions are more easily controlled, and the photos are more explicit. The government agencies of Thailand have started to use more and more drones, making them faster and more accurate in their work, but some problems exist between the government agencies. No photo data from drones are shared. The researcher thinks that it will be better if, in the government agency, drone photo data is collected and made in the form of Big Data, accessible to only Thai government agencies. Save the budget and save the time of the government agency itself.

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