DIGITAL MAPPING OF SURFICIAL DEPOSITS
IN SI MAHOSOT AREA, CHANGWAT PRACHINBURI

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A REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF THE BACHELOR OF SCIENCE IN GEOLOGY

DEPARTMENT OF GEOLOGY
FACULTY OF SCIENCE
CHULALONGKORN UNIVERSITY

ACADEMIC YEAR 2015

การทำแผนที่ดิจิตอลของตะกอนผิวดินในพื้นที่ศรีมโหสถ จังหวัดปราจีนบุรี

นางสาวนิพิษฐา พงษ์พานิช

รายงานฉบับนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรบัณฑิต

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ปีการศึกษา 2558

Date of submission

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Date of approval

______/______/______

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Abstract

The study of the digital surficial mapping scales 1:50,000 is in Amphoe Si mahosot of Changwat Prachinburi and Amphoe Phanom Sarakham of Changwat Chachoengsao. The area comprises approximately 723 square kilometers. The extents of coordinates of the study area are approximately defined as 1540000 N, 736000 E northwestern edge and 1516000 N, 767000 E southeastern edge in Universal Transverse Mercator projection with 47 North zone (UTM 47N) in WGS 1984 ellipsoid. The objectives of the research is to study and generate digital surficial deposits map by using digital method which are visual classification and supervised classification from Landsat 8 OLI/TIRS image together with and digital elevation model (DEM) for analysis and interpretation.

The result is shown that the surficial units in the study area can be classified into 8 units, namely; unit A, unit B, unit C, unit D, unit E, unit F, unit G and unit H. Each surficial unit has differences digitally characteristics, physical properties of sediments, elevation from MSL and spectral range which are related to geomorphology, depositional environments and land uses. The limitation of this study is the effect of urban disturbance that can be made the mistakes in analysis and interpretation. The mistakes can be corrected by field observation. Furthermore, the technique from this study may be used to further use to systematic map the surficial deposits in the other low land areas in the river floodplain basin with less time in the large area and should be very productive to update for the more accurate surficial deposits. Besides, the result from this study is hopefully to be further fruitful applied to be used for better land use management and mitigation of the natural disasters in the study area in the future.

KEYWORD: Digital mapping, Surficial deposits, Si Mahosot, Prachinburi, Chachoengsao

ชื่อโครงการ	การทำแผนที่ดิจิตอลของตะกอนผิวดินในพื้นที่ศรีมโหสถ จังหวัดปราจีนบุรี DIGITAL MAPPING OF SURFICIAL DEPOSITS IN SI MAHOSOT AREA, CHANGWAT PRACHINBURI
ภาควิชา	ธรณีวิทยา
ชื่อนิสิตหัวหน้าโครงการ	นางสาวนิพิษฐา พงษ์พานิช **รหัสประจำตัวนิสิต** 5532724923
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บทคัดย่อ

การจัดทำแผนที่ตะกอนผิวดินมาตราส่วน 1:50,000 บริเวณพื้นที่อำเภอศรีมโหสถ จังหวัดปราจีนบุรี และอำเภอพนมสารคาม จังหวัดฉะเชิงเทรา จำนวน 725 ตารากิโลเมตร ในขอบเขตพื้นที่ 1540000N-151600N และ 736000E-767000E ตามพิกัดภูมิศาสตร์ระบบ UTM 47N, WGS 1984 เพื่อศึกษาและจัดทำแผนที่ตะกอนผิวดินโดยใช้การวิเคราะห์ข้อมูลดิจิตอลที่ได้มีการศึกษาต้นแบบตามมาตรฐานสากล ด้วยวิธีการจำแนกข้อมูลด้วยสายตา และการวิเคราะห์ด้วยวิธีการจำแนกประเภทข้อมูลแบบควบคุม (Supervised classification) โดยใช้ข้อมูลภาพถ่ายจากดาวเทียม Landsat 8 OLI/TIRS (Panchromatic band 8) ข้อมูลแบบจำลองความสูงเชิงตัวเลข และข้อมูลการตรวจสอบในภาคสนาม ร่วมกันในการวิเคราะห์ประมวลผลและแปลความหมาย

ผลจากการศึกษาในครั้งนี้สามารถจำแนกหน่วยตะกอนผิวดิน ได้ทั้งหมด 8 หน่วย ได้แก่ หน่วยตะกอน A หน่วยตะกอน B หน่วยตะกอน C หน่วยตะกอน D หน่วยตะกอน E หน่วยตะกอน F หน่วยตะกอน G และหน่วยตะกอน H โดยหน่วยตะกอนผิวดินแต่ละหน่วยมีความแตกต่างกันของลักษณะทางกายภาพของตะกอนผิวดิน ระดับความสูงจากระดับน้ำทะเลที่สะสมตัว และช่วงคลื่นของการตรวจวัด ซึ่งมีความสัมพันธ์กับการสะสมตัวตามธรณีสัณฐาน การพัฒนาของหน้าดิน การตั้งถิ่นฐาน และการใช้ทรัพยากร สำหรับข้อจำกัดของการศึกษาครั้งนี้พบว่า ในบางบริเวณที่มีความหนาแน่นของชุมชนเมืองทำให้การวิเคราะห์ประมวลผลและแปลความหมายเกิดความผิดพลาดได้ ซึ่งสามารถตรวจสอบได้จากข้อมูลภาคสนาม นอกจากนั้นวิธีการที่ใช้ในการศึกษาครั้งนี้ คาดว่าจะสามารถนำไปประยุกต์ใช้ทำให้แบ่งหน่วยตะกอนผิวดิน ที่สามารถนำไปทำการปรับปรุงการทำแผนที่หน่วยตะกอนผิวดินของที่ราบลุ่มน้ำของประเทศไทยในพื้นที่อื่นๆ ได้อย่างเป็นระบบ ที่มีความละเอียดมากขึ้น ภายในเวลาและงบประมาณที่จำกัด ซึ่งข้อมูลจากการศึกษาในครั้งนี้ยังสามารถนำไปประยุกต์ใช้ประโยชน์ในการวางแผนการจัดการและการใช้พื้นที่ รวมทั้งการลดผลกระทบจากพิบัติภัยจากธรรมชาติในพื้นที่ศึกษาต่อไป

คำสำคัญ: แผนที่ดิจิตอล ตะกอนผิวดิน ศรีมโหสถ ปราจีนบุรี ฉะเชิงเทรา

Acknowledgement

It is a genuine pleasure to express my deep sense of thanks and gratitude to my project's advisor, Asst.Prof.Dr. Sombat Yumueng who continually teach and advice in regard to project and Mr.Katawut waisusri who guide and support techniques and data for this project. Without their guidance and help this project would not have been possible.

I would like to thank these organization which are GISTDA, GISTHAI, Land development department and Department of mineral resources that supported digital data for analysis.

In additional, a thank you to my team members, Mr.Irapot Saengrayab and Miss.Nicharee Asokanan, who would assist field observation. Moreover, my family and my friends, GEO'56, who is always encourage me through my project is completed.

Contents

Pages

List of figures

Figures | Pages

Figures Pages

List of Table

Chapter 1

Introduction

1.1 Rationale

Surficial deposits or superficial deposits refer to geological deposits or unconsolidated sediment typically less than 2.6 million years. These recent sediments are defined by its physical properties i.e. grain size, composition and attached to an interpretation how the unit formed. Examples of surficial lithology is floodplain deposits, beach sands, talus gravels and moraine. Surficial geological survey is significant to land management, land development, disaster management and hazard evaluation, such as flood, drought and debris flow hazard (McGraw-Hill Dictionary of Scientific & Technical Terms, 2003*)*

In the traditional geological mapping that focus on the interpretation from aerial photos with field data. This technique takes long period and uses an individual expertise that make the different standard in data interpretation.

Nowadays, the technologies and digital data advances, such a digital elevation model (DEM) and Satellite images, improve the digital geological mapping in details, more accurate and more precise. The processes of digital geological mapping are data collection, data analysis and data synthesis. Moreover, Remote sensing technique that is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation (Schowengerdt, 2007) and Geographic information system technique (GIS) that is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data (Kenneth et al., ***2015)*** are applied to mapping with field data for correction.

The traditional mapping can be applied to the digital mapping by import the geological field data and access them to geographic information system database that can be analyzed in spatial, improved data and used as a standardized data collection. These techniques are improved and controlled by International geological survey; united states geological survey (USGS), Geological survey of Canada (GSC), British geological survey (BGS), etc. Moreover other private sectors apply these techniques in various fields such as geological map of mine, geological map of hot spring etc. Then, a successful in field observation and digital mapping consists the good database and using remote sensing technique and GIS technique in efficient.

In Thailand, The geographic information system has been used by Department of mineral resources (DMR) since 2004.The DMR manipulates all field data and accesses them to standardize database for reduce the data duplication and plan to use the GIS for manage ASEAN geospatial data in the same standard. Whilst the DMR improve and develop system, other countries study on the digital mapping of surficial deposits from the digital data by using the remote sensing and GIS technique to create the surficial deposits map with high accuracy and precision and applied the data to their land management such as the regional mapping of surficial basin deposits in central death valley, USA (Jayko et al., 2005), flood hazard mapping by digital data in the Vugia-Thu bon alluvial plain, Vietnam (Ho et al., 2010) and Surficial materials mapping in Nunavut, Canada (LaRocque et al., 2012)

The central plain Thailand is the largest sedimentary deposits which is divided into 2 parts; the upper central plain and the lower central plain. The upper central plain that the average height is 40-60 meters above sea level, shows undulating terrain and has the Ping River, Wang River, Yom River and Nan River are the major rivers. The lower central plain that the average height is 2.5-20 meters above sea level, shows the avulsion of the Chao Praya River which consist marsh, tidal flat, delta, beach and sand bar. (DMR, 2007)

Study area is Si Mahosot area locates in the west of the lower central plain that is divided into widely sedimentary units. There are coastal tidal dominated deposits, fluvial deposits terrace deposits, colluvium deposits and bedrocks. Therefore, the senior project is aim to study the digital mapping of surficial deposits in Si Mahosot area, Prachinburi province in details by using digital data, digital methods with field observation for correction and creates in the GIS database.

1.2 Objectives

The purposes of this present study area are study the digital mapping of surficial deposits by using remote sensing and geographic information system techniques with field observation for correction and create surficial deposits of Si Mahosot area in scale 1:50,000

1.3 Study area

Si Mahosot area (Figure 1-2) is located in provincial boundary that is Amphoe Phanom Sarakham of Chachoengsao province and Amphoe Si Mahosot of Prachinburi province, Central Thailand (Figure 1-1). The major river is Bang Prakong River that is located in the western of study Area. The River shows features of meandering river and flow direction from North to south. The study area cover approximately 723 square kilometers. The extents of coordinates of the study area are approximately defined as 1540000 N, 736000 E northwestern edge and 1516000 N, 767000 E southeastern edge in Universal Transverse Mercator projection with 47 North zone (UTM 47N) in WGS 1984 ellipsoid.

The geological map of study area (Figure 1-3) shows sediments and rock units that consist Granite (Trgr); Conglomerate, Phyllite, Tuffaceous sandstone (C2); Chert, Tuff, Limestone, Volcanic rocks (Trpn); Colluvium deposits, Terrace deposits, Fluvial deposits and coastal tidal dominated deposits. (DMR, 2007)

1.4 Scope of study

This senior project is the analysis of geospatial data; Landsat 8 OLI/TIRS with digital elevation model (DEM) in Si Mahosot area. The digital methods are composed of visual interpretation, unsupervised classification, supervised classification and normalized difference vegetation index classification (NDVI). This project aim to create digital map of surficial deposit in Si Mahosot area scales 1:50,000 and further correctby collecting ground truth data from field observation in the locations between unit boundaries, in addition, access all data in GIS database.

1.5 Expected results

1.5.1 Surficial deposits map of Si Mahosot area scales 1:50,000 with GIS database

1.5.2 A prototype of surficial deposits map by using digital method that may be applied in other similar geological areas for further study in the future

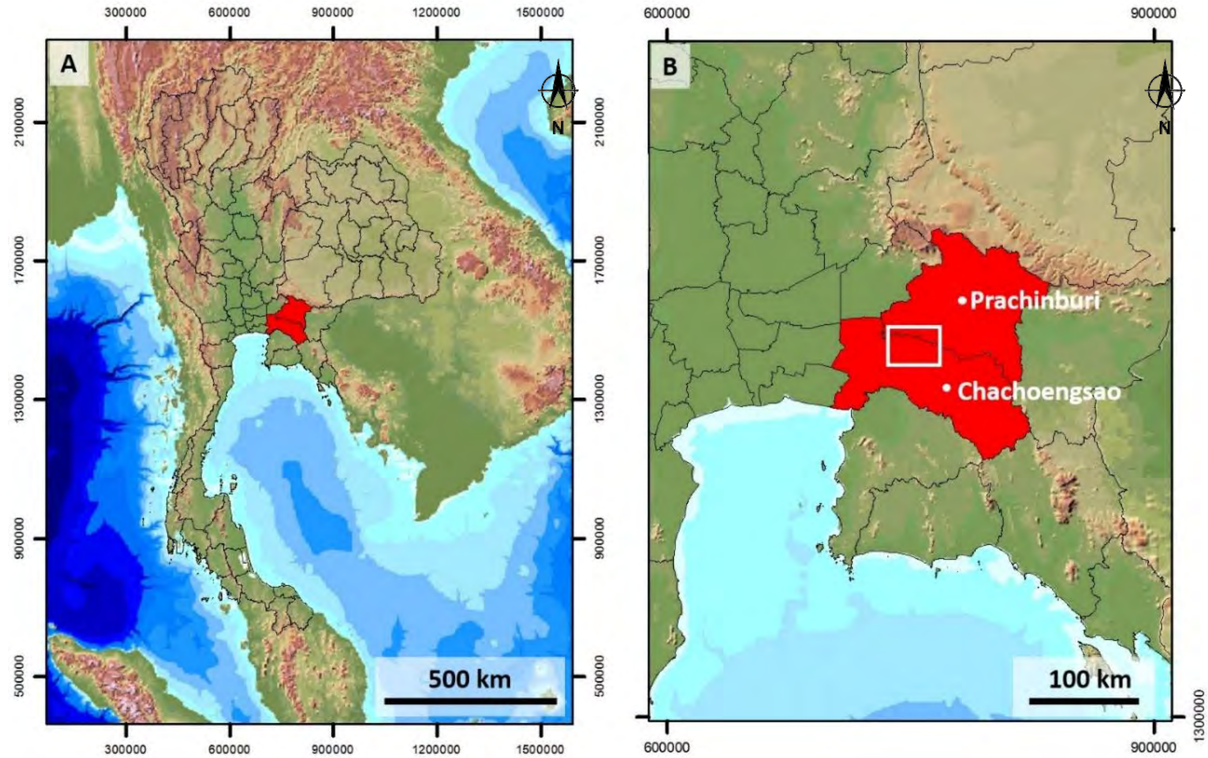

Figure 1-1 (A) The location of Prachinburi province and Chachoengsao province. (B) The study area is in white frame.

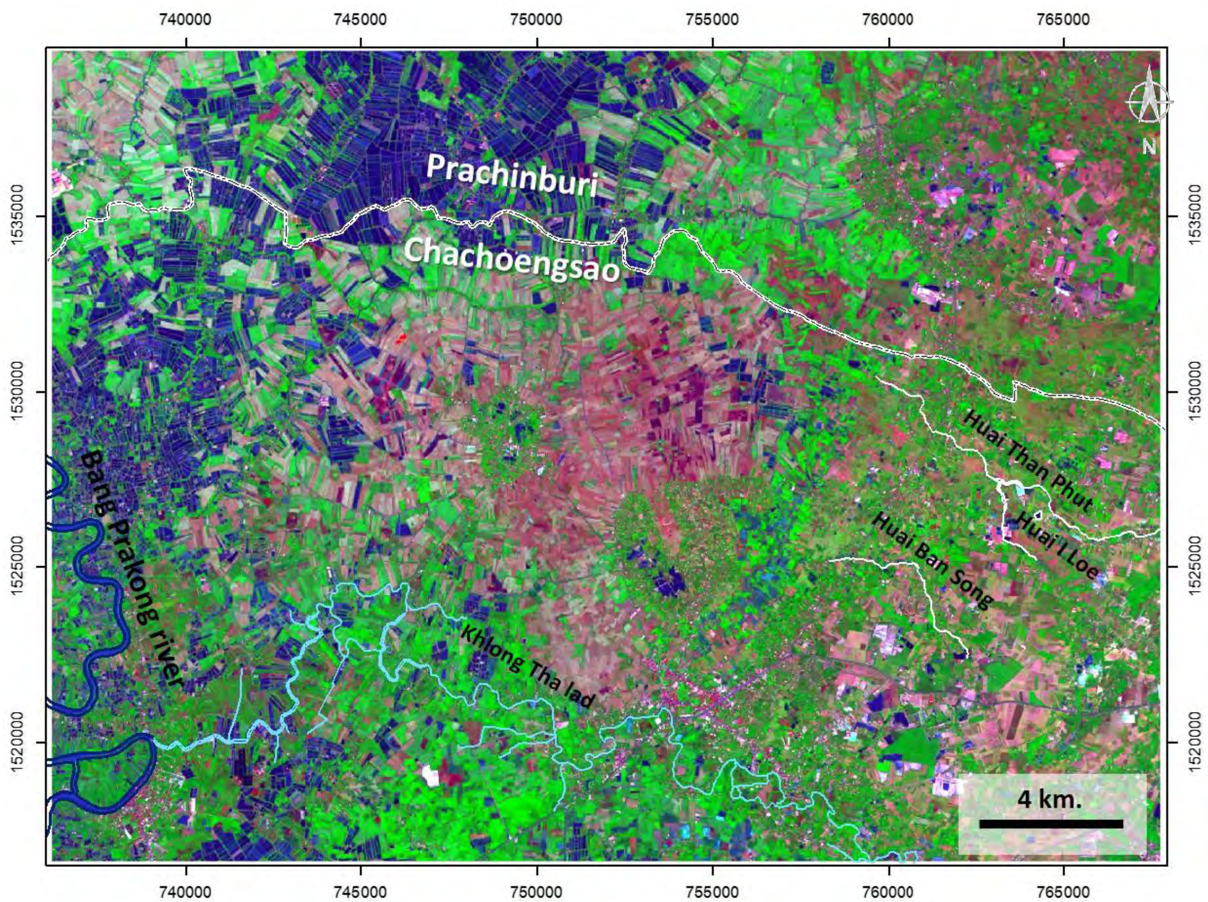

Figure 1-2 Satellite image (Landsat 8 OLI/TIRS (RGB: 754) Path 129 Row 050) of Si Mahosot

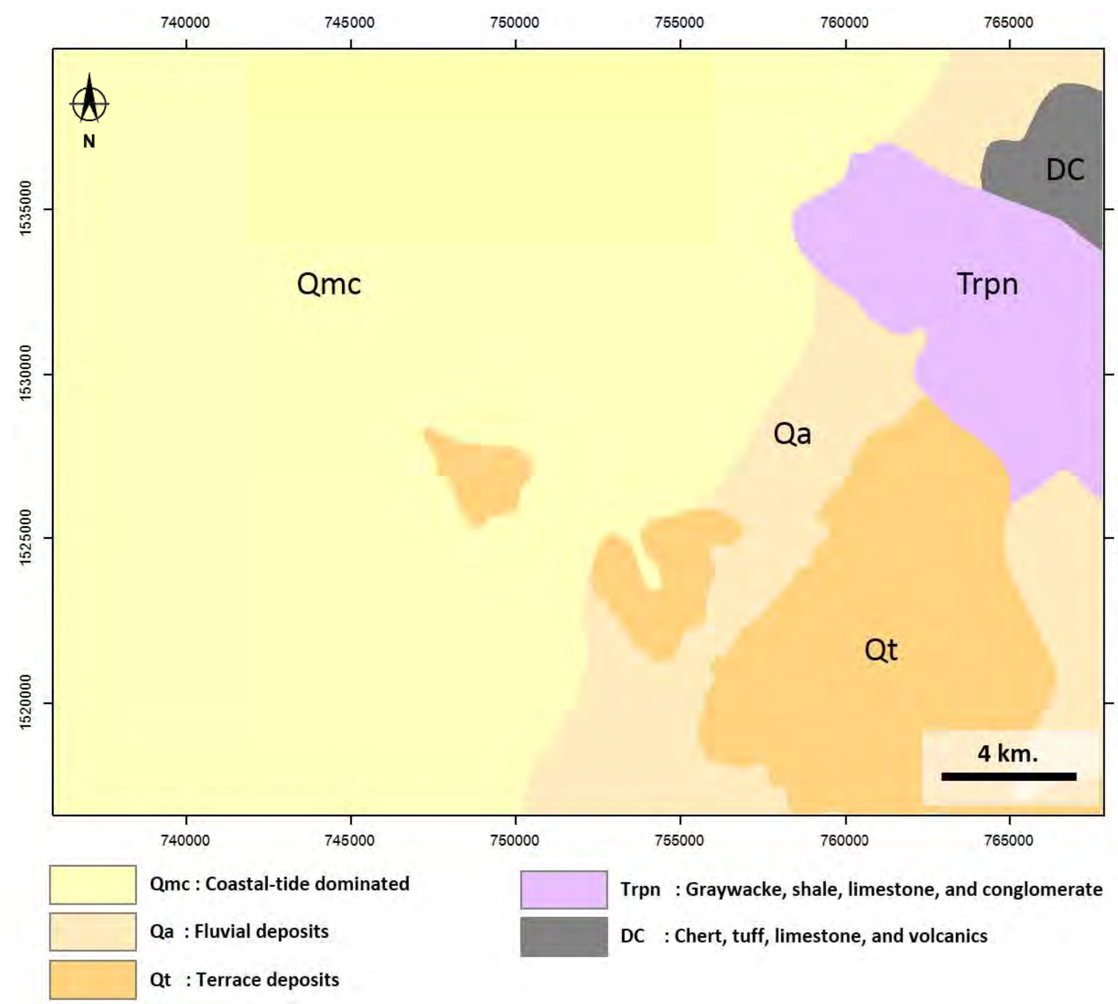

Figure 1-3 Geological map of Si Mahosot area scale 1:250,000 (DMR, 2007)

1.6 Research methodology

1.6.1 Mapping Methods

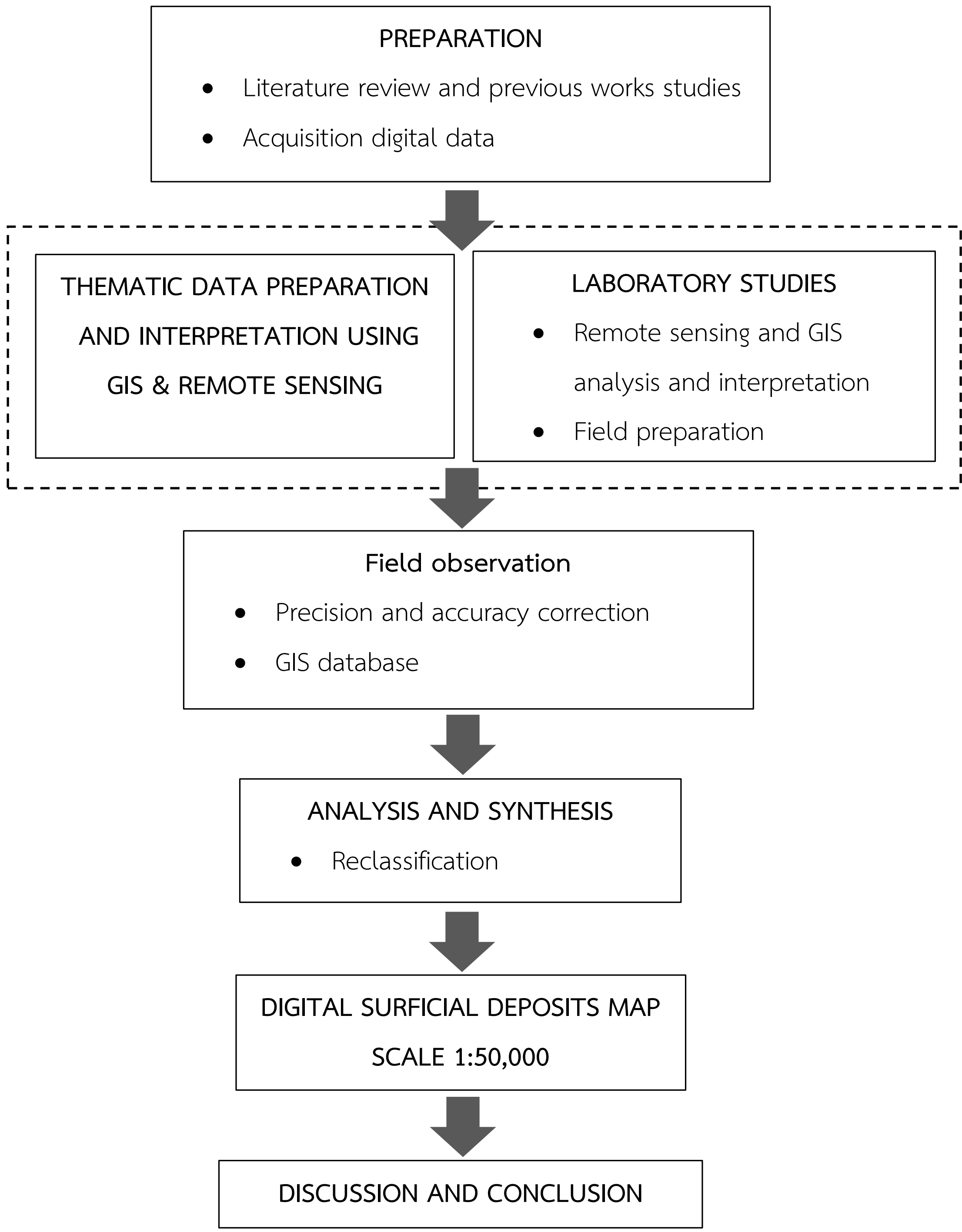

Figure 1-4 Schematic diagram presents the research methodology system

1.6.2 Research procedure

The schematic diagram (Figure 1-4) which was designed illustrates the methodology system and the details are shown as follows:

1.6.2.1 Preparation

This step includes:

- Study literature reviews and previous works of study area, Central Thailand and other counties.
- Acquisition digital data and basic data of study area i.e. Satellite images of Medium resolution (Landsat 8 OLI/TIRS), Topographic map, Geological map (1:50,000 and 1:250,000 scales), Digital elevation data (DEM), Soil unit map (1:25,000 scale) and related data.

1.6.2.2 Data preparation and interpretation using GIS and remote sensing

1.6.2.3 Laboratory studies

The laboratorial analysis is conducted as follows:

- Softwares of geographic information system (GIS) and remote sensing ,there are Arcmap 10.2.2 and ERDAS IMAGINE 2014 are applied in store, manipulate, analyze, manage, analysis and present all types of spatial or geographical data.
- Interpretation of satellite images (medium resolution) that is Landsat 8 OLI/TIRS (15 meters spatial resolution) with digital elevation data by using digital methods. These methods are visual interpretation, unsupervised classification and normalized difference vegetation index classification. This sub-step consist of data digitization, data analysis, data synthesis and data processing.
- Field preparation is create field observation locations map from previous sub-steps (data analysis) and designs GIS database.

1.6.2.4 Field observation

- Field observation for precision and accuracy correction in along surficial unit boundaries by using field observation locations map from previous step.
- Update GIS database

1.6.2.5 Analysis and synthetic

- Data reclassification is a combination of field data from field observation and analytical data from laboratory study, then synthesis data and create Digital surficial map (1:50,00 scale)
- Updates GIS database

1.6.2.7 Discussion and conclusion

- Discussing and concluding surficial units in Si Mahosot area.
- Limitations

Chapter 2

Literature reviews and Regional Geology

2.1. Satellite image

Landsat 8 was launched on February 11, 2013. It is collecting valuable data and imagery to be used in agriculture, Education, Business, Science and Government.

The Landsat 8 satellite images entire the earth every 16 days. It carries 2 instruments; the operational land imager (OLI) sensor and the thermal infrared sensor (TIRS). These sensors both provide improved signal-to-noise (SNR) performance enable better.

Pixel size for OLI multispectral band 1-7 is 30 meters, OLI panchromatic band 8 is 15 meters, TIRS bands 10 to 11 is collected at 100 meters resolution, but are resampled to 30 meters in data product (USGS, 2016).

2.1.1 Band details (Loyd, 2013)

2.1.1.1 Band 1- Coastal/aerosol is deep blues and violets. This light is scattered easily by dust and water in air. The main uses of this bans are imaging the shallow water and tracking the particles. Its output looks similar with band 2 but if it is contrasted, it will look differences.

2.1.1.2 Band 2, band 3 and band 4 are Blue, green and red, respectively, is closed to natural color that use for detect land uses and to compare with the other bands.

2.1.1.3 Band 5- Near infrared (NIR). This wavelength is scattered by water in healthy leaves, thus it is important for ecology studies and measure density of plant in area.

2.1.1.4 Band 6 and band 7 is shortwave infrared (SWIR). It use for distinguish rocks and soil because SWIR make a stronger contrast between them than other bands.

2.1.1.5 Band 8 is panchromatic- its spatial resolution is 15x15 meters. It combines with other bands to improve the resolution of band.

2.1.1.6 Band 9 is Cirrus. Atmosphere absorb this wavelength, thus the ground show visible in this band but it must be reflect above of atmosphere which is high cloud.

2.1.7 Band 10 and band 11 is Thermal infrared (TIRS). It detect heat instead of temperature of air.

Table 2.1 Band names, Wavelength and Resolution of Landsat 8 OLI/TIRS bands (Gao et al, 1995).

Bands	**Wavelength (micrometers)**	**Resolution (Meters)**
Band 1 – Coastal aerosol	0.43-0.45	30
Band 2 – Blue	0.45-0.51	30
Band 3 – Green	0.53-0.59	30
Band 4 – Red	0.64-0.67	30
Band 5 – Near Infrared (NIR)	0.85-0.88	30
Band 6 – SWIR 1	1.57-1.65	30
Band 7 – SWIR 2	2.11-2.35	30
Band 8 – Panchromatic	0.50-0.68	15
Band 9 – Cirrus	1.36-1.38	30
Band 10 – Thermal Infrared (TIRS) 1	10.60-11.19	100
Band 11 – Thermal Infrared (TIRS) 2	11.50-12.51	100

2.2 Methodology

Satellite image interpretation can be analyzes into 2 methods; Visual classification and Digital image classification which cooperate with digital elevation model (DEM).

2.2.1 Visual classification

Visual classification is one of techniques that interpret the digital images by analyst. The digital images will be extracted by the differentiation between target and background and will be compared the different targets based on visual element which are color, pattern, texture, shape, size and association.

Shape is typical form, structure and outline of objects which is important for interpretation. Size is function of scale which related to other objects that assists in the interpretation. Texture is image frequency of tone, there are rough texture and smooth texture which assist to interpret features. Pattern is spatial arrangement that the similar of tone and texture produce a distinctive pattern. Association is the relationship between objects or feature (CCRS, 2016).

2.2.2 Digital image classification (Digital method)

Digital image classification uses the quantitative spectral information of images that are related to composition and condition of the surface. This method which requires an understanding the difference materials on the surface absorb, reflect and emit the radiation in differences spectral values which is based on different color in multispectral image which result of the different composition and condition of objects, radiometric is cause by the different brightness and spatial that related to ground distance. The digital method consists of supervised classification and unsupervised classification (Schuckman, 2014).

2.2.2.1 Supervised classification uses to identify training sites from digital image to represent each unit. Each unit may have different spectral characteristics. For example, the spectral signature of a water body will depend on the amount of suspended sediment or plant material in the water.

2.2.2.2 Unsupervised classification which use algorithm to search and analyses the digital image. The pixels are group into cluster and it be representative of unit.

2.2.2.3 Normalized differences vegetation index (NDVI) are spectral transformation of bands to become a standard part of vegetation monitoring that are estimate vegetation properties, Precision farming and monitor natural vegetation. The vegetation indices is derived from field, airborne and satellite data.

The NDVI is one of the vegetation indices. It is a normalized ration of near infrared (NIR) and red band of visible light (Rouse et al, 1974). The ratio is following this equation

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

2.2.3 Histogram equalization

Histogram equalization is technique in image processing for enhancement of image. This method is non-linear enhancement which is enhancing the contrast of image with the sample distribution that distributes pixel values uniformly. (Raju et al, 2008)

2.3 Previous works

Analog mapping by conventional techniques is consistently define unit boundaries from aerial photo characteristics. The variation of conventional mapping can be changed by quality of photo, Photo scales and interpretative biases among individual (Jayko et al, 2005). Until systematic field and air photo mapping is applied, the interpretation of remote sensing and digital elevation model (DEM) is used for surficial deposits.

The satellite images which are Landsat, SPOT and RADARSAT are used to distinguish surficial units by the different of digitally characteristics of the image and geomorphic feature. Each satellite data have different qualification and usability.

The Landsat image, panchromatic images is spatial resolution 15x15 meters (Figure 2-1), is used in surficial mapping and others works. Due to the properties of satellite image can be informed basin characteristics in regional scale and analyst can generate the band combination that suitable for studies. These abilities can be easier classified distinguish units than ever. Moreover, spectral differentiation of the image can be classified both the complexity area such as piedmonts deposits and glacial deposits and the simple area such as flood plain deposit and Playa deposits. Thus, RADARSAT image (Figure 2-2) that will be compatible because this image has a synthetic aperture radar (SAR) with multiple polarization mode (CSA, 2007). It is made a better classification (LaRocque et al., 2012) and use digital elevation data to landform classification.

Various remote sensing methods that use with satellite image and Digital elevation model (DEM) which are Normalized difference (Maskava et al.. 2008) vegetation index method for vegetation indication, Normalized difference water index and modified normalized difference index methods that are combination of Green band, near infrared band (NIR) and middle infrared (MIR) for study about water and moist soil (Ho et al, 2010), visual classification and digital method for surficial and geological mapping (Jayko et al,2010) (LaRocque et al, 2012).

The result of the digital mapping is a systematic regional mapping and can be distinguished the unit from digitally characteristics, spectral differentiation (Figure 2-3), Radiometric differentiation and spatial differentiation. However, this method should be applied with field observation to study the physical properties of surficial deposits or materials and correct the accurate of the interpretation.

The application of digital surficial deposits is groundwater studies (Soller et al, 2009), monitoring agricultural change, flood hazard mapping (Ho et al, 2010) and detection of the environmental changes.

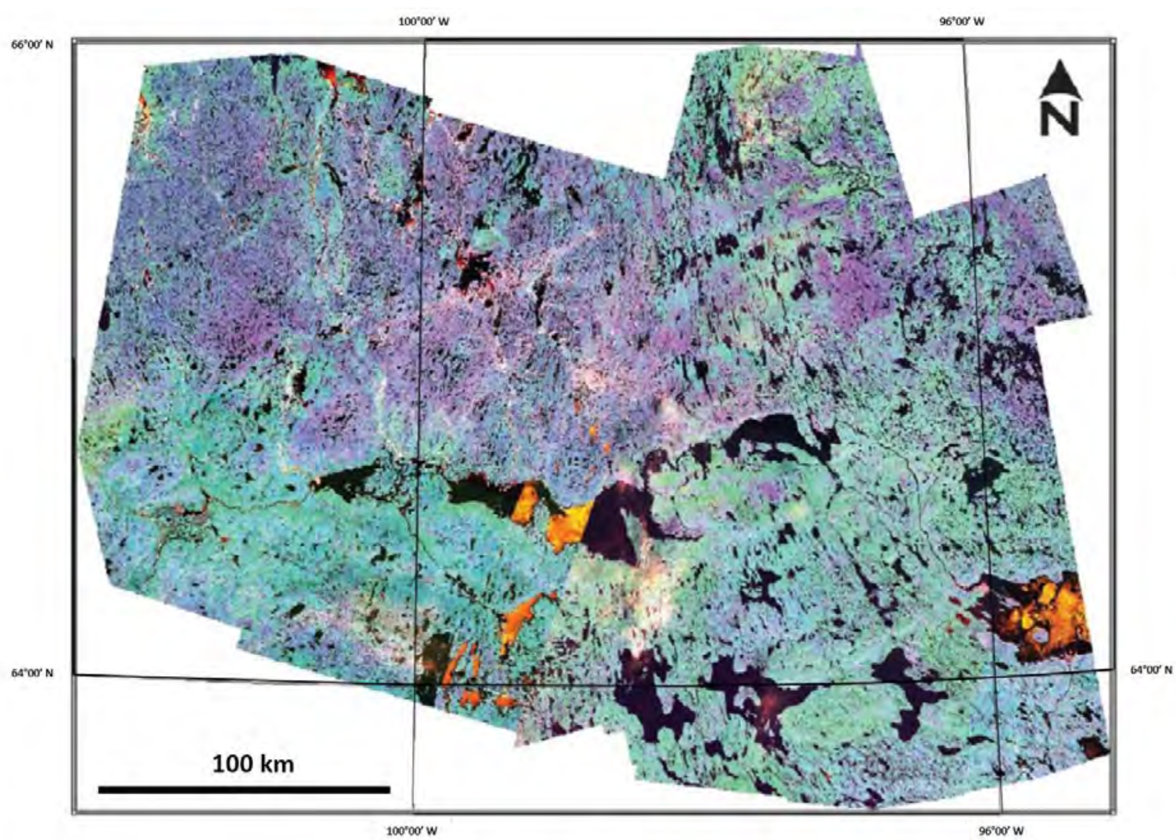

Figure 2-1 Landsat 7 ETM+ (RGB: 345) at the northeast Thelon region (LaRocque, 2012)

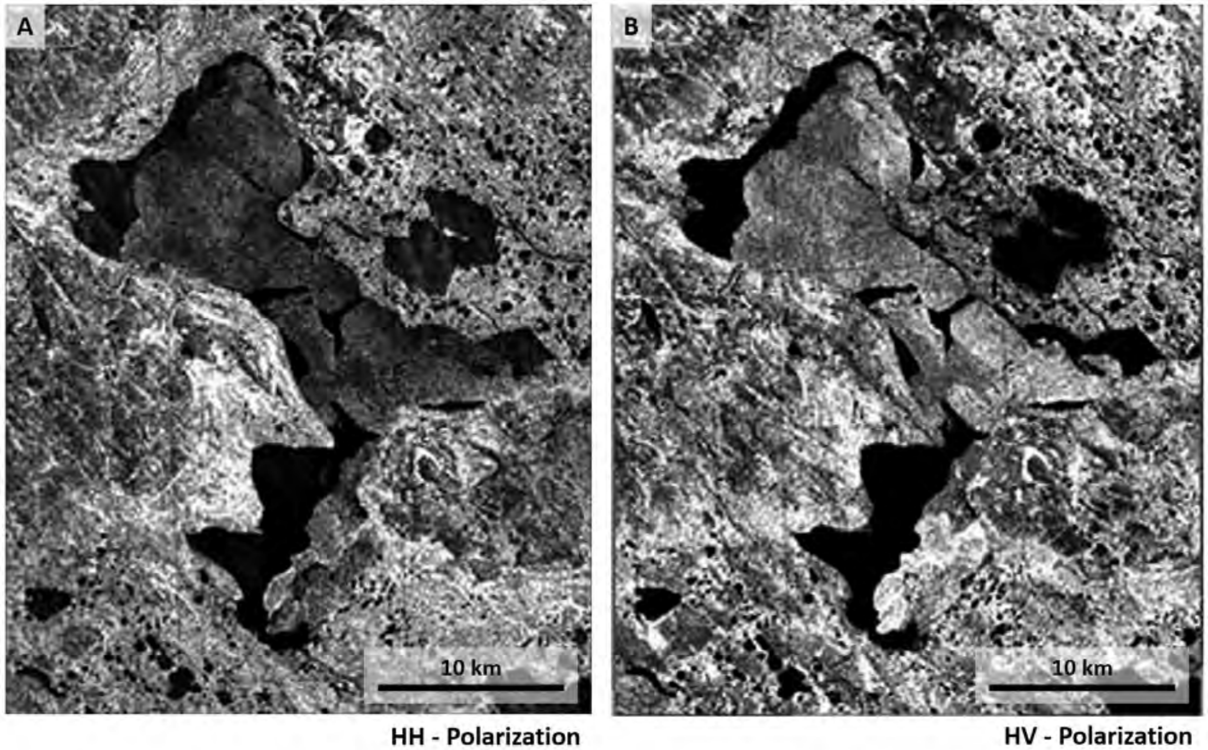

Figure 2-2 Radarsat 2 Dual-polarization are (A) C-HH polarization and (B) C-HV polarization at Pitz lake (LaRocque, 2012)

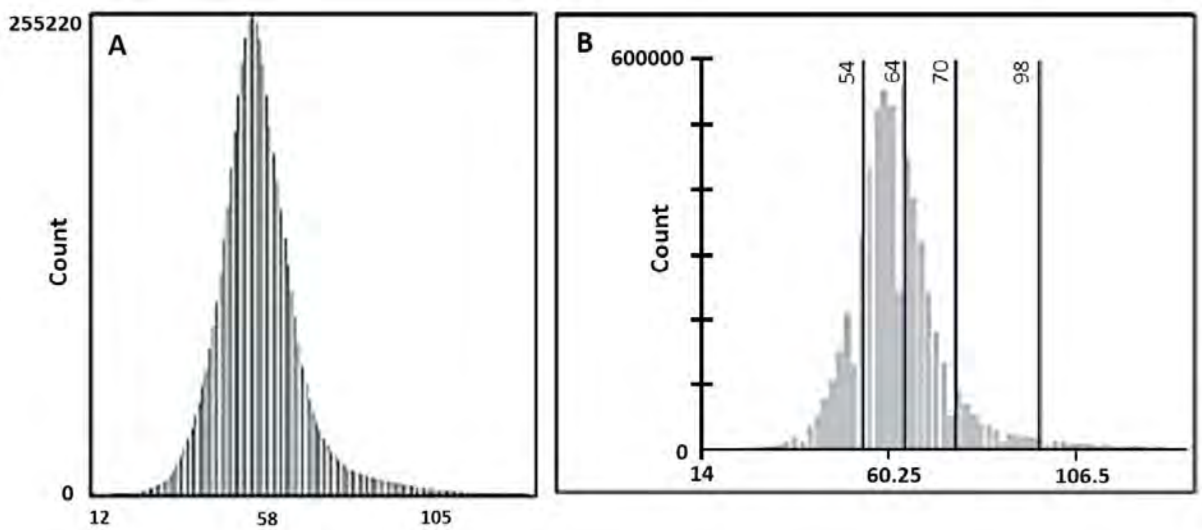

Figure 2-3 (A) Spectral range of Landsat 7 band 8, Fan domain and (B) Spectral range of Landsat 7 TM band 8 analyze by 1-16 degree slope area at Death Valley (Jayko et al., 2005)

2.4 Regional Geology

Surficial deposits are unconsolidated sediment which overlies bedrock or occurs near the surface of the earth that were deposited in Quaternary period which subdivided into 2 epochs; Pleistocene and Holocene. Quaternary period concerned about the climate change, sea-level change and landform evolution. The classification of quaternary sediments in Thailand are based on geomorphology, lithology and depositional environments. The Pleistocene deposits were related to neo-tectonics and alluvial and fluvial system. The Holocene deposits were mainly climate changes and marine sediment that related to the fluctuated sea level.

The central plain of Thailand is covering the broad plain of the Chao Phraya River which subdivided into 2 regions. There are upper central plain and lower central plain (Figure 2-4).

The upper central plain extends south to southern part of Nakhon Sawan Province below point of the joining of Ping River and Nan River. This area is undulating terrain that have average elevation is 40-60 meters from mrean sea level (DMR, 2007). The depositional environments are alluvial fans and fluvial landforms. (Choowong, 2011)

The lower central plain is area which extends from Nakhon Sawan to the gulf of Thailand. Its average elevation is about 2-4 meters (MSL). Landforms of this area are largely flat delta plain (Thiramongkol, 1983). The quaternary deposits of this area is interaction between terrestrial and transitional environment. (Choowong, 2011)

The terrestrial landforms which are piedmont fans deposit in Pleistocene epoch that occurs along eastern margin and its characteristics is undulating surfaces and consists of laterite bed on ground or below surface, Terraces in the western of plain is occurred by Mae Klong River and Suphanburi River whilst in the eastern of plain is occurred by Bang Prakong river and alluvial fans are active fans in the western margin there are Don chedi fan and Mae Klong fan (Thiramongkol, 1983 and Choowong, 2011).

The transitional environment which overlaps between lower central plain and coastal of the gulf of Thailand. There are deltaic plain deposits, brackish deposits, intertidal and marine deposition are formed as tidal-influenced deposition and estuaries with salt marsh and mangrove which shows as Bangkok clay and peat.

The study area is located between Prachinburi Province and Chachoengsao Province which is in the eastern margin of the lower central plain of Bang Prakong river that flows from north to south out to gulf of Thailand. The landforms of study area is terrace deposits and old tidal flat (Sinsakul, 2000). The terrace contains gravel, sand, silt, clay and laterite that are overlying bedrocks which are sedimentary rocks and metamorphic rocks. The old tidal flat has been influenced by fluvial environment that contain gravel, sand silt and clay from fluvial deposition and comprise coastal-tide environment and estuary. There are composed of clay, silt and fine-grained sand of tidal flat with marsh, mangrove and swamp (DMR, 2007).

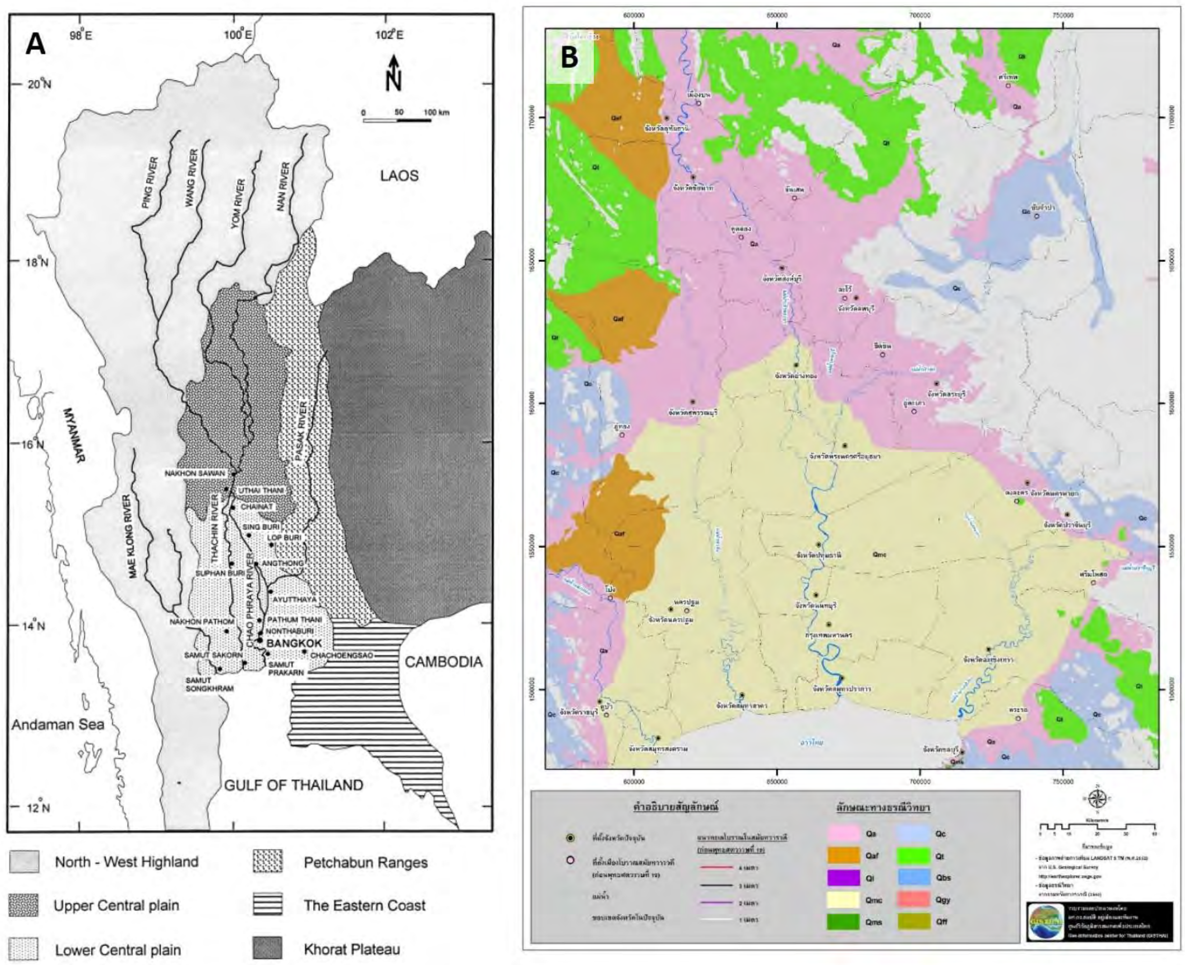

Figure 2-4 The Central plain of Thailand by (A) Sinsakul (2000) and (B) GISTHAI (2015)

Chapter 3

Research procedure

3.1 Preparation

To complete the objectives of this study, the research methodology will be start from the preparation of the previous works and related information that has been reviewed and collected, as well as the methods and techniques of the digital analysis to be used.

3.2 Thematic data acquisition and preparation

The input data used for surficial classification in this study consists of several spatial data categories from the available resources (Table 3-1) and the detail of each data is shown in Acquisition thematic data or digital data of the study area as follow:

3.2.1 Acquisition thematic data or digital data of the study area

3.2.1.1 Landsat 8 OLI/TIRS imagery of study area acquired on 20th January 2015, the date of image should in the same season or month of field survey date. The satellite data is path 129 and row 50 designation. Image spatial resolution is 30x30 meters (Figure 3-1).

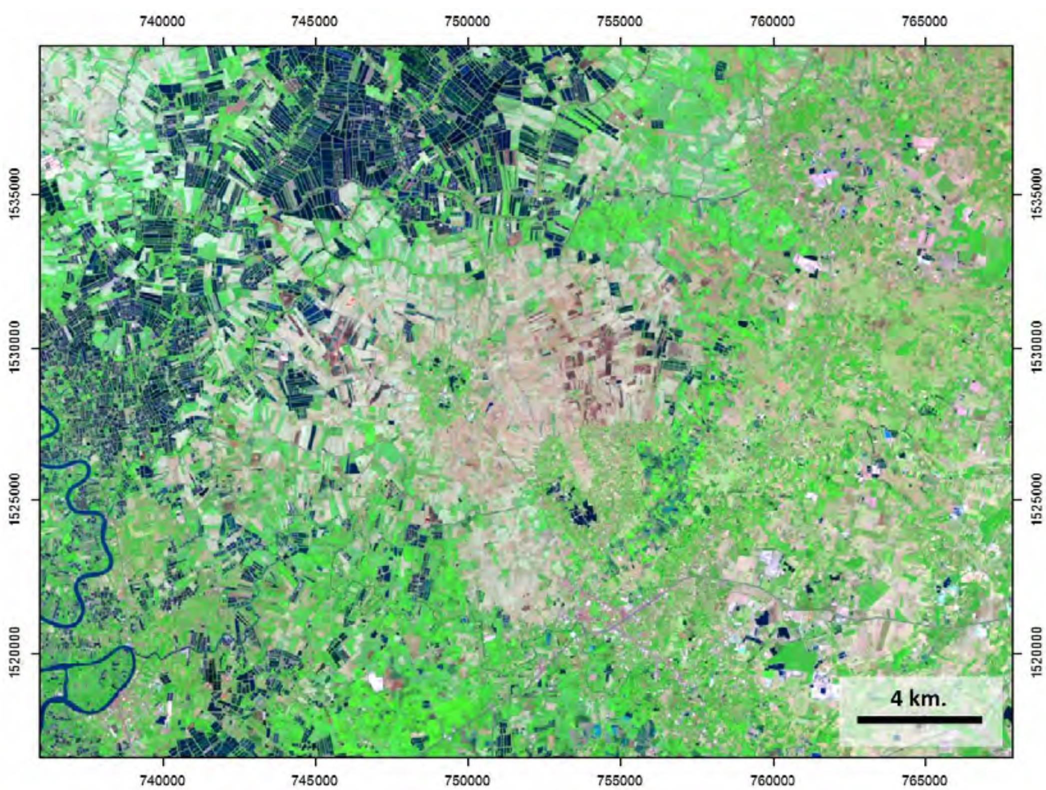

Figure 3-1 False color image (RGB: 654) of Landsat 8 OLI/TIRS (Path 129 Row 50) of study area. That was acquired on 20th January 2015

3.2.1.2 Topographic maps of study area is 1:50,000 scale from the Royal Thai Survey Department (RTSD). These map is 1-RTSD edition and series L7018 (Figure 3-2).

Map sheets: 5236I Amphoe Si mahosot

5236II Amphoe Phanom sarakham

5236III Changwat Chachoengsao

5236IV Amphoe Bang nam priao

5336III Ban Cham pa ngam

5336IV Amphoe Kabi Buri

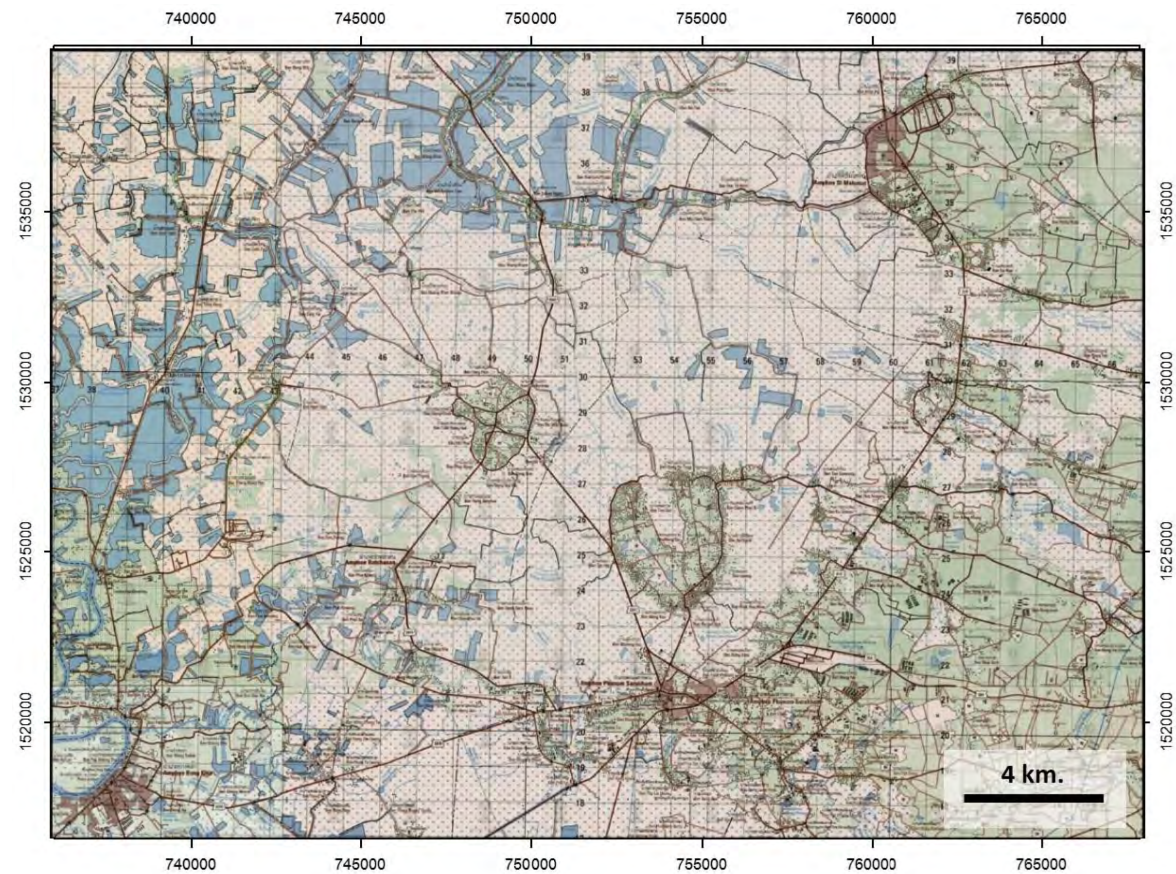

Figure 3-2 Topographic map of study area (RTSD, 2007)

3.2.1.3 Normalized difference vegetation index (NDVI) is converted from Landsat 8 OLI/TIRS following this equator

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

NIR is near infrared wave which is Band 5 of Landsat 8 OLI/TIRS and Red is visible light in red range which is band 4 of Landsat 8 OLI/TIRS. The NDVI image indicates vegetation density (Figure 3-3) that shows more vegetation in the north, west and middle of the study area.

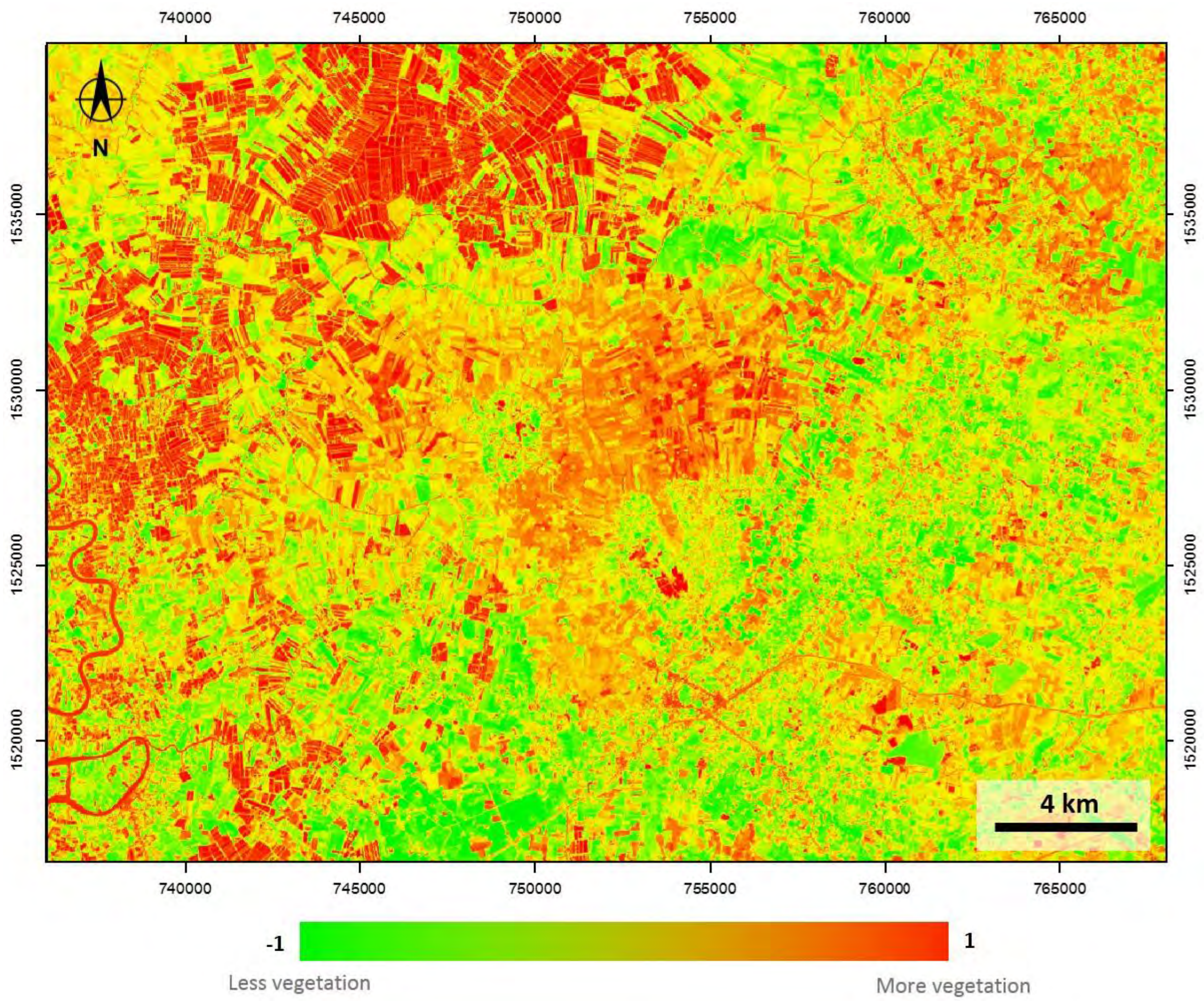

Figure 3-3 Normalize difference vegetation index (NDVI) of study area

3.2.1.4 Digital elevation model

Digital elevation model or DEM is three-dimension model that represents of terrain's surface. There are 1 meter vertical resolution and 5x5 meters in spatial resolution that is the digital data from Land development department (LDD).

It is noted that the mainly part of the study area is flat plain with the elevation of 2 meters from MSL whereas the higher land forms as terrace and gentle hills are located in the southern-west part of the study area with the elevation of 10- 59 meters from MSL as shown in Figure 3-4.

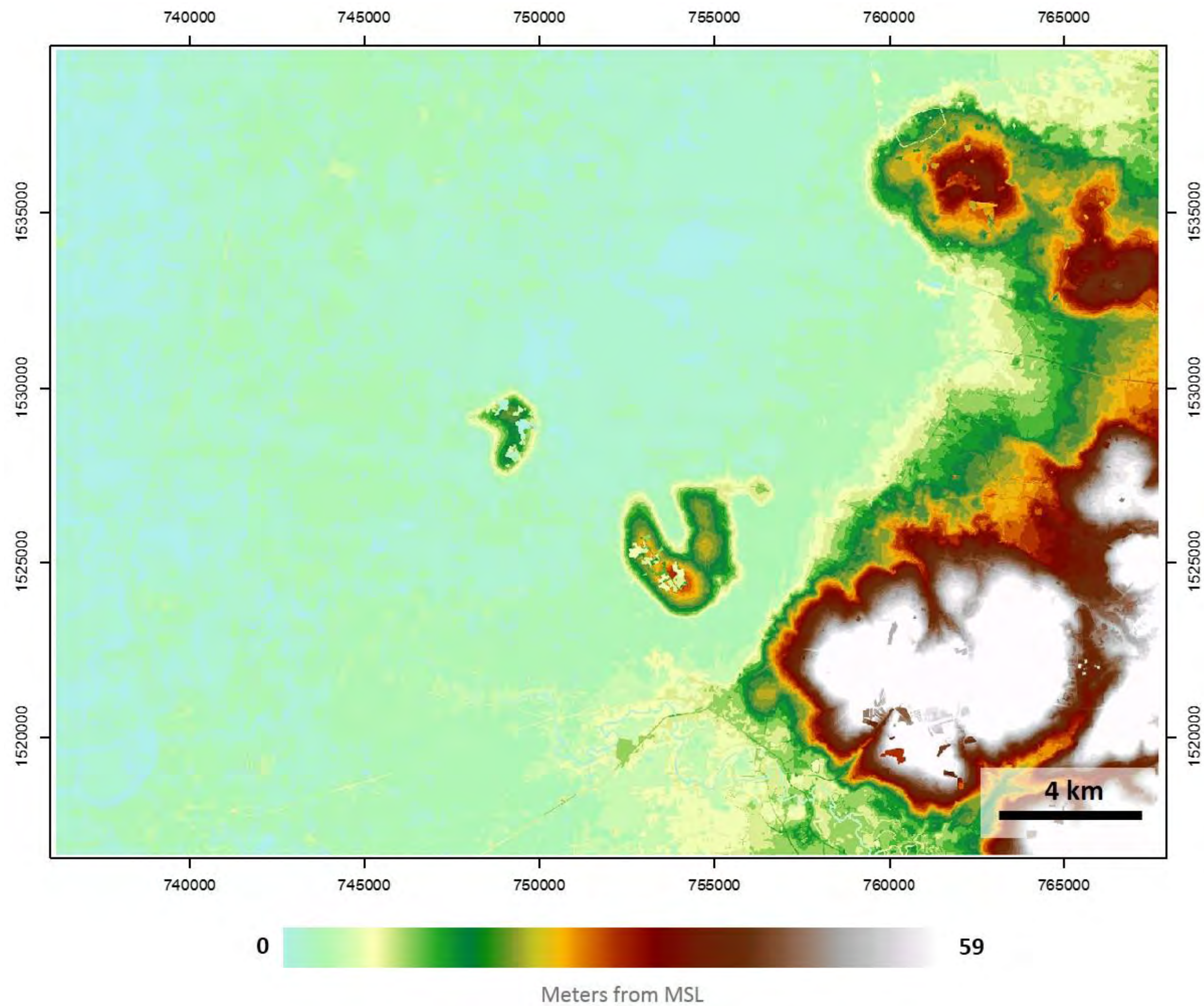

Figure 3-4 Digital elevation model of the study area (LDD, 1997)

3.2.1.5 Hill shade

Hill shade (Figure 3-5) is converted from DEM. It shows contour line. It shows more detail of features related to the elevation of the surface. It is also shown the morphological characteristics concordance to the DEM of Figure 3-4.

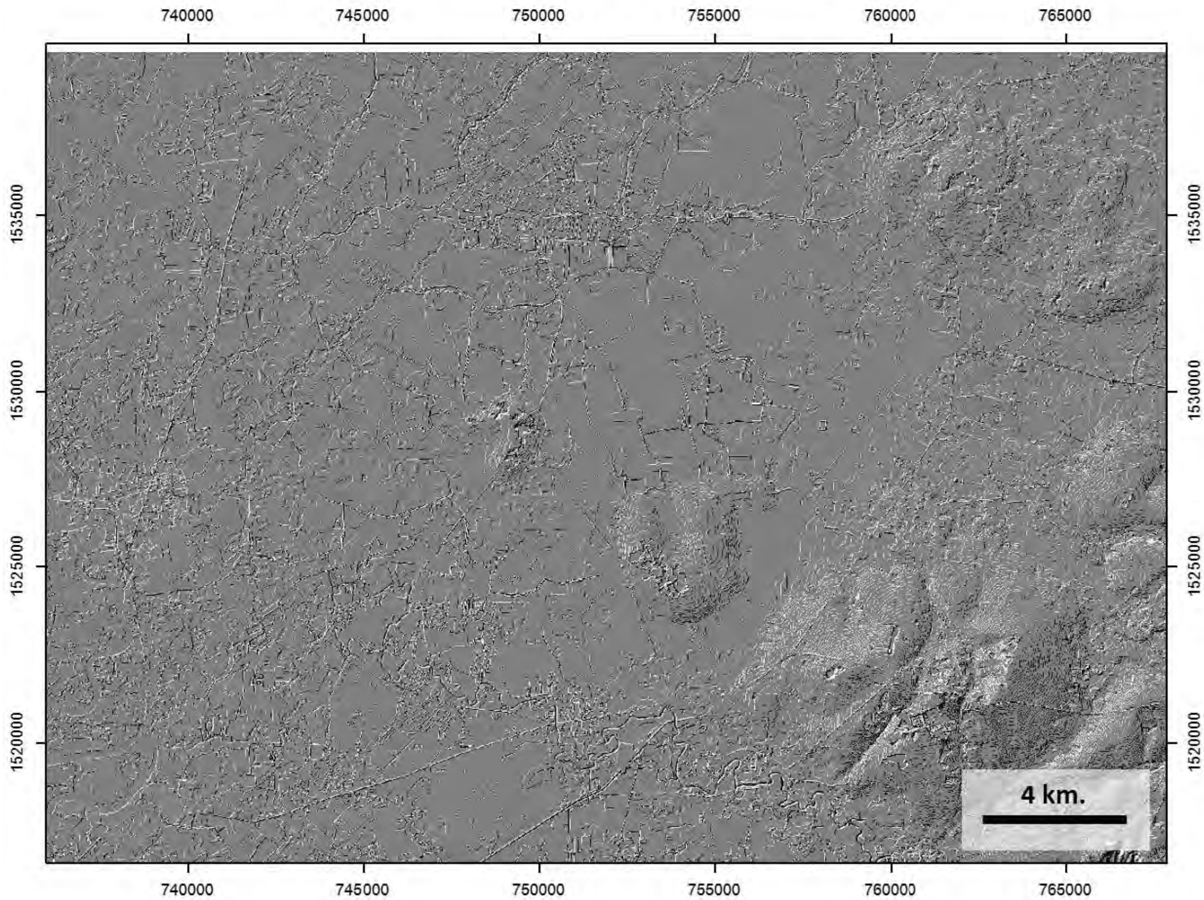

Figure 3-5 Hill shade map of the study area

3.2.1.6 Geological units

Geological units boundaries of study area in 1:250,000 scale as shown in figure 3-6 is derived from the Department of Mineral Resources (2007). Geological units were classified into 4 units. There are bedrocks, which are consist of Trpn unit (sedimentary rocks) and DC unit (sedimentary rocks and metamorphosed rocks); Terrace deposits (Qt); Fluvial deposits (Qa) and Coastal-tide dominated deposits (Qmc), respectively

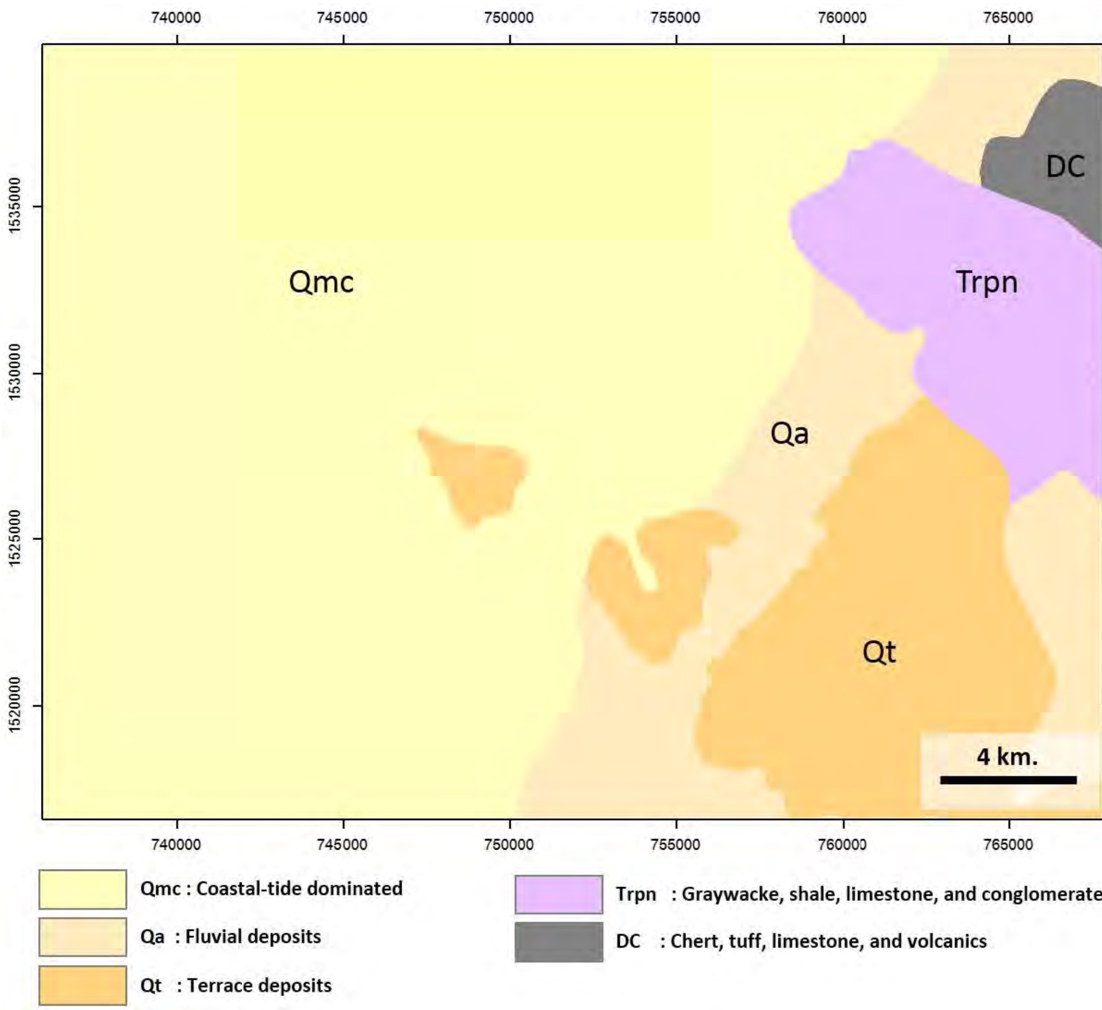

Figure 3-6 Geological map of study area (DMR, 2007)

3.2.1.7 Soil units

Soil map of study area (Figure 3-7) and soil properties is 1:50,000 scale which derived from Land development department. The soil map is focusing to use as information for land use and soil resource management.

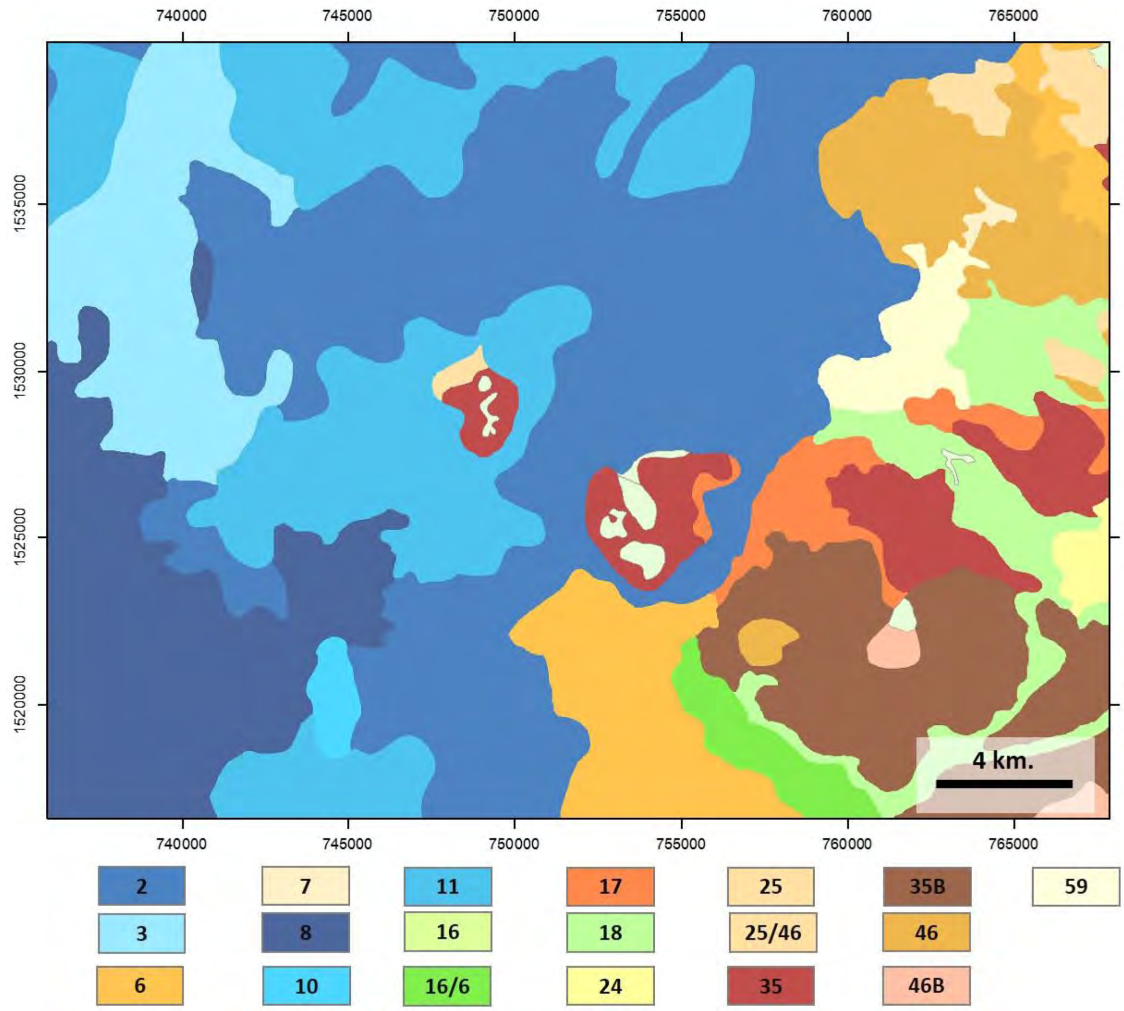

Figure 3-7 Soil unit map of study area (LDD, 2011). See description of index in appendix.

3.2.1.8 Transportation, River and Water bodies shape file.

Table 3-1 Overview of the important input data

Main themes	Sub-themes	Data preparation methodology
Rater data	Landsat 8 OLI/TIRS imagery	Derived from USGS (earthexplorer.usgs.gov)
	Topographic map	Derived from a 1:50,000 scale, topographic map of the Royal Thai Survey Department (2000)
	Normalized difference vegetation index (NDVI)	Converted from Landsat 8 OLI/TIRS imagery
Elevation	Digital elevation model (DEM)	Derived from Land Development Department (LDD)
	Slope	Converted from DEM with GIS
	Hill shade	Converted from DEM with GIS
Geology	Rock unit boundaries	Derived from a 1: 250,000 scale geological map of Department of mineral resources (DMR)
Soil properties	Soil unit	Derived from a 1:50,000 soil map of Land Development Department.
Vector data	Transportation	Derived from a 1:50,000 scale, topographic map of the Royal Thai Survey Department (2000)
	Rivers and water bodies	Derived from a 1:50,000 scale, topographic map of the Royal Thai Survey Department (2000)

3.3 Laboratories study

This step is image analysis and interpretation by Remote sensing technique and GIS technique; visual classification, supervised classification. The results from this step is used to prepare for the field observation map location.

3.3.1 Thematic preparation

3.3.1.1 Pan sharpening the imagery

This process is merging the high resolution panchromatic band (band 8 black and white color image) which is 15x15 meters spatial resolution with lower resolution multispectral imagery that is 30x30 meters spatial resolution (Figure 3-8A) to create a high resolution color image in 15x15 meters spatial resolution (Figure 3-8B). Then, Pan-sharpened image is used to analysis and classification.

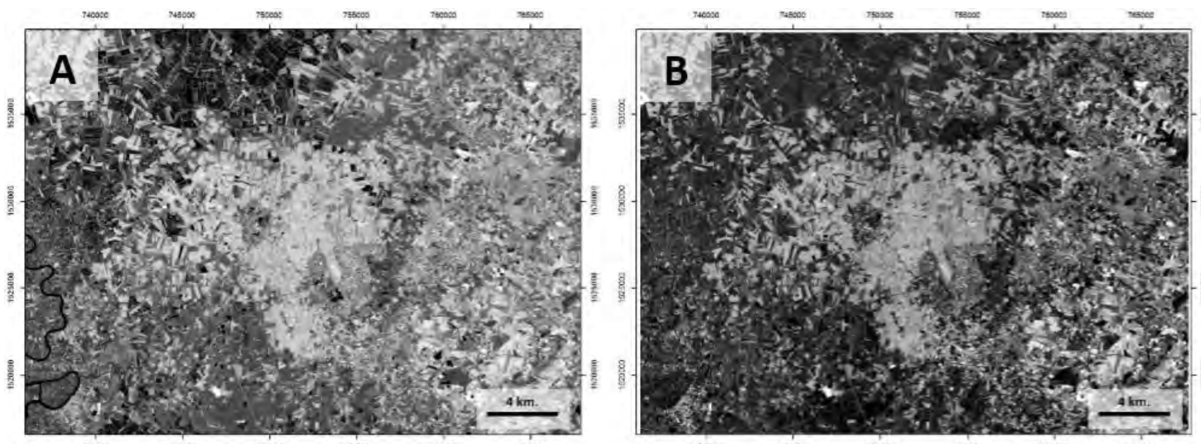

Figure 3-8 Pan-sharpening imagery that improve the resolution from (A) 30x30 meters spatial resolution to (B) 15x15 meters spatial resolution

3.3.1.2 Histogram Equalization

This method is improve contrast of digital image. It leads better views of structure and better detail in image. The histogram equalize image (figure 3-9) is used in visual classification and supervised classification

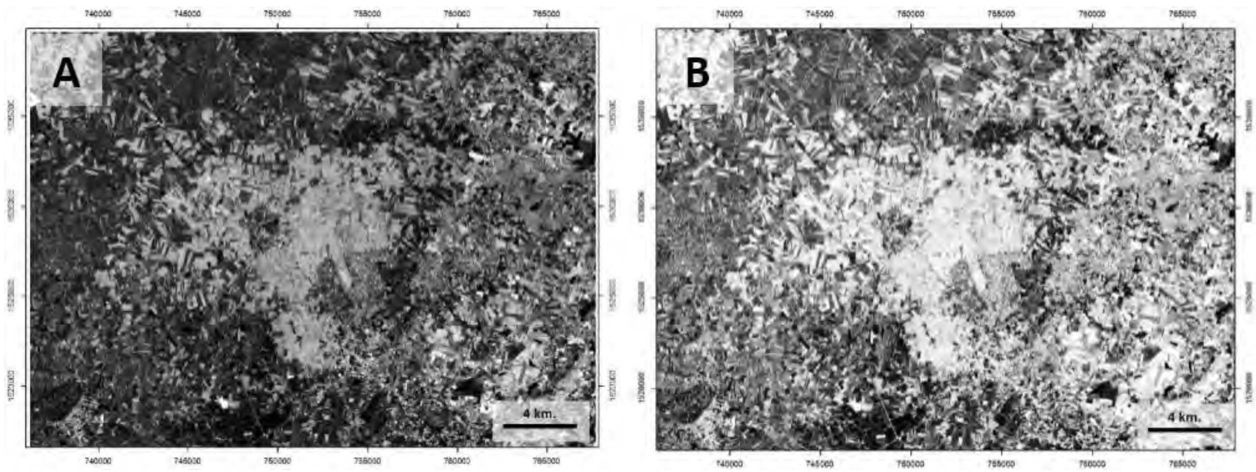

Figure 3-9 Histogram Equalization the improve contrast of image (A) to image (B)

3.3.1.3 Remote sensing technique

This process is image classification by visualization. Visual classification is identify surficial units and geological features from Landsat 8 OLI/TIRS RGB: 777, RGB: 432 and RGB: 127, respectively, based on differences of color, texture, pattern, shape, size and position together with DEM. The database table is designed for visualize data register.

3.3.2 Thematic data analysis and interpretation

3.3.2.1 Visual classification

Study area is divided into 9 classes by differences of color, texture, pattern and shape of digital image. The digital image use 3 band combination image as shown in RGB which are 777, 432 and 127, respectively. There are unit A, Unit B, Unit C, Unit E, Unit F, Unit G, Unit H and Unit I. The details and distributions of these units are described as shown in Table 3-2 and Figures 3-8 to 3-22.

- Band combination for visual classification.

Band combination 777 (Figure 3-10), this band combination shows stronger contrast between rocks and soil than other bands.

Band combination 432 (Figure 3-11), this band combination is close to true color but it tend to be susceptible to atmospheric interference. So, the digital image should be less of cloud.

Band combination 127 (Figure 3.12), this band combination shows differences of wet earth and dry surface. The contrast between blue which is dry earth and yellow which is wet surface.

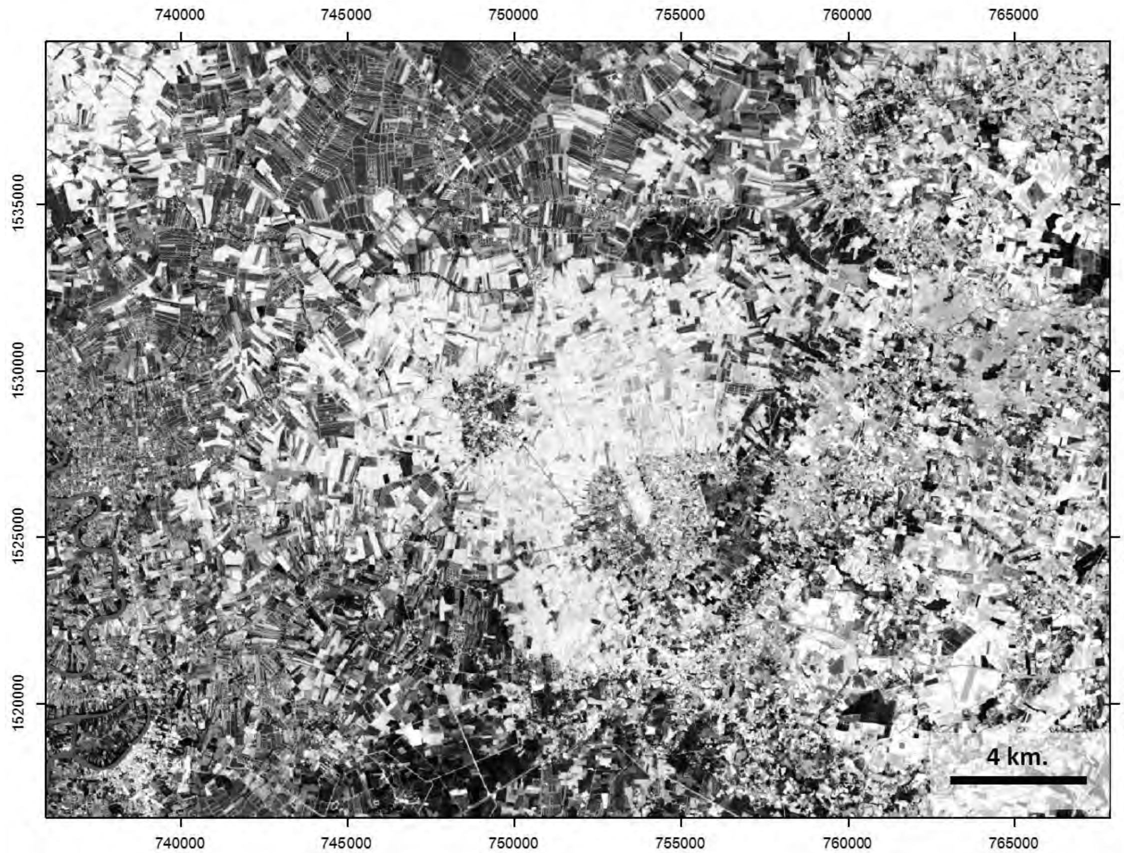

Figure 3-10 Landsat 8 OLI/TIRS of study area (RGB: 777)

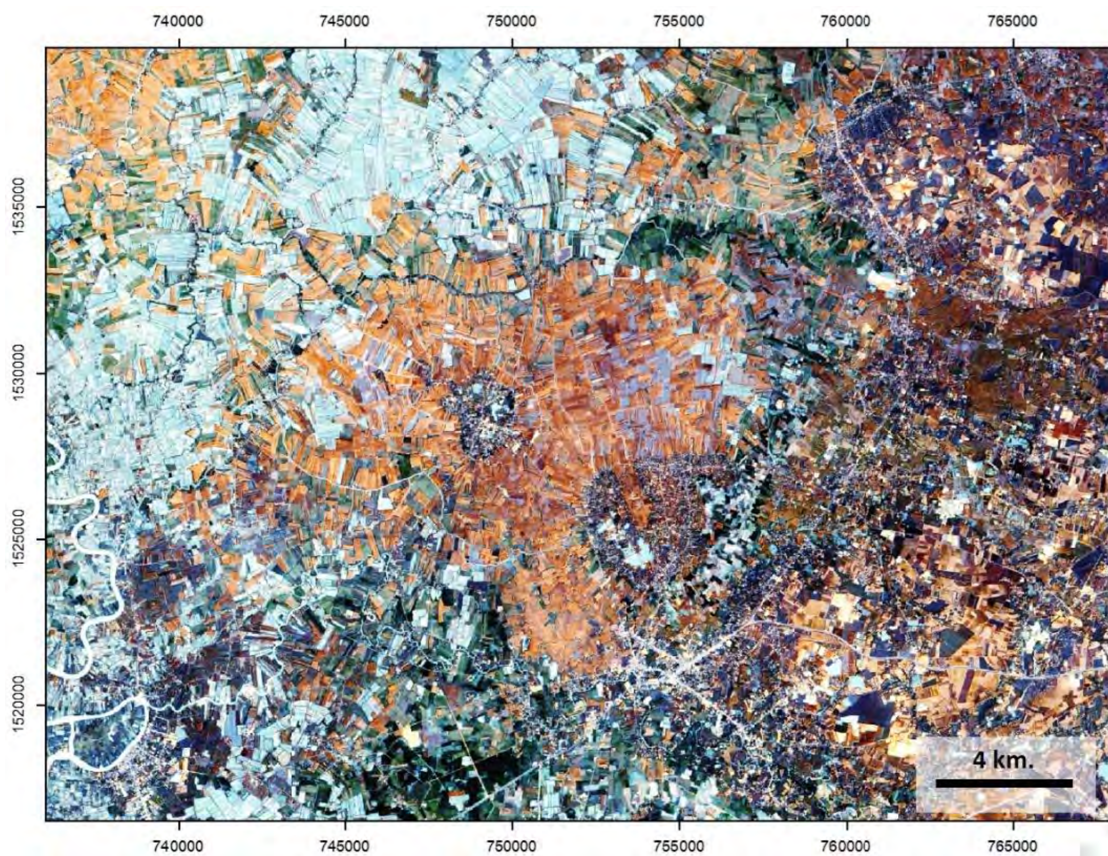

Figure 3-11 Landsat 8 OLI/TIRS of study area (RGB: 432)

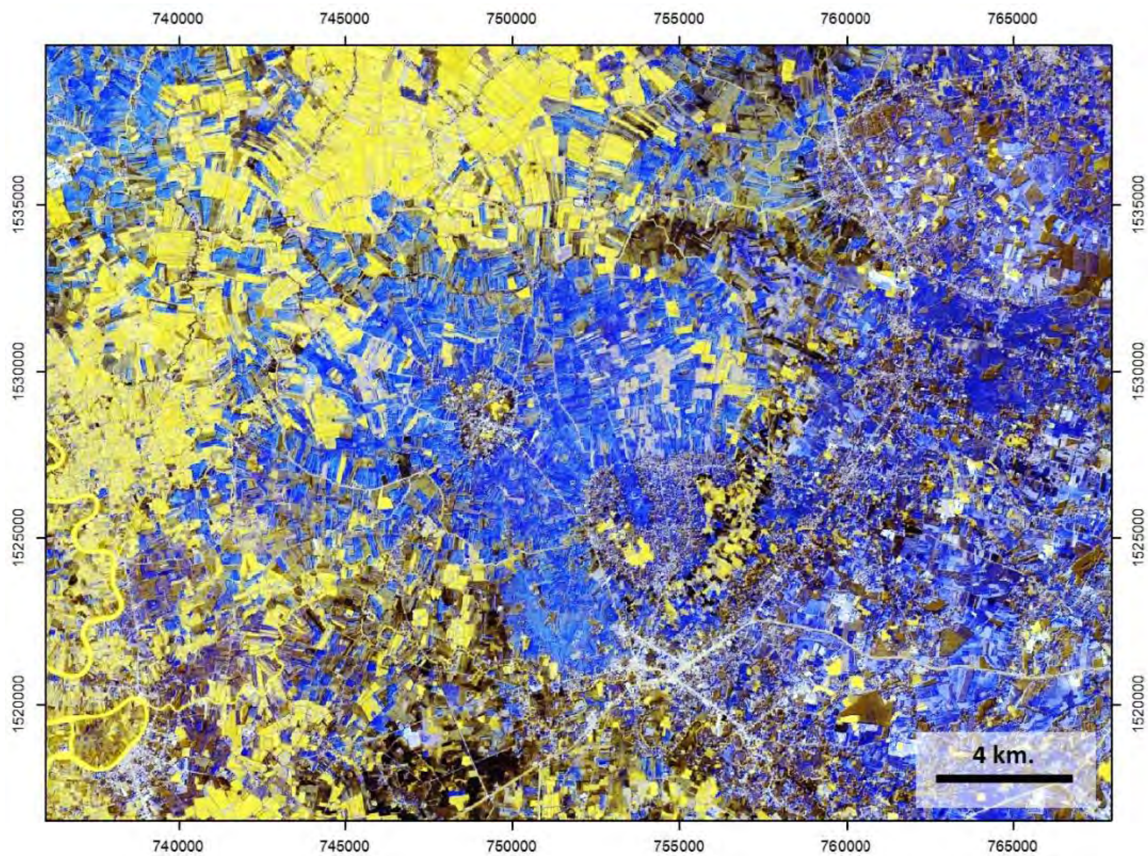

Figure 3-12 Landsat 8 OLI/TIRS of study area (RGB: 127)

Table 3-2 Visual classification of Landsat 8 OLI/TIRS (RGB: 777)

Unit	Color			Texture	Pattern	Shape	Position/Relation	figure
	Bl	Gr	Wh					
A	30	10	60	Smooth		Polygon	Located more than 20 meters in DEM	3-13
B	20	70	10	Rough	Dot	Polygon	Used RGB: 127 to separate with unit C	3-14
C	20	70	10	Rough	Dot	Sphere and linear	Located on slope change and elevation 2-10 meters	3-15
D	10	80	10	Smooth		Polygon		3-16
E	35	35	30	Rough	Dot	Polygon	Located alond Khlong Tha Lad	3-17
F	10	10	80	Smooth	Square	Polygon		3-18
G	70	20	10	Smooth	Square	Polygon		3-19
H	10	70	10	Smooth	Square	Polygon	Lowest vegetation cover	3-20
I	10	70	10	Rough	Small square	Polygon	Locat alond Bang Prakong river	3-21

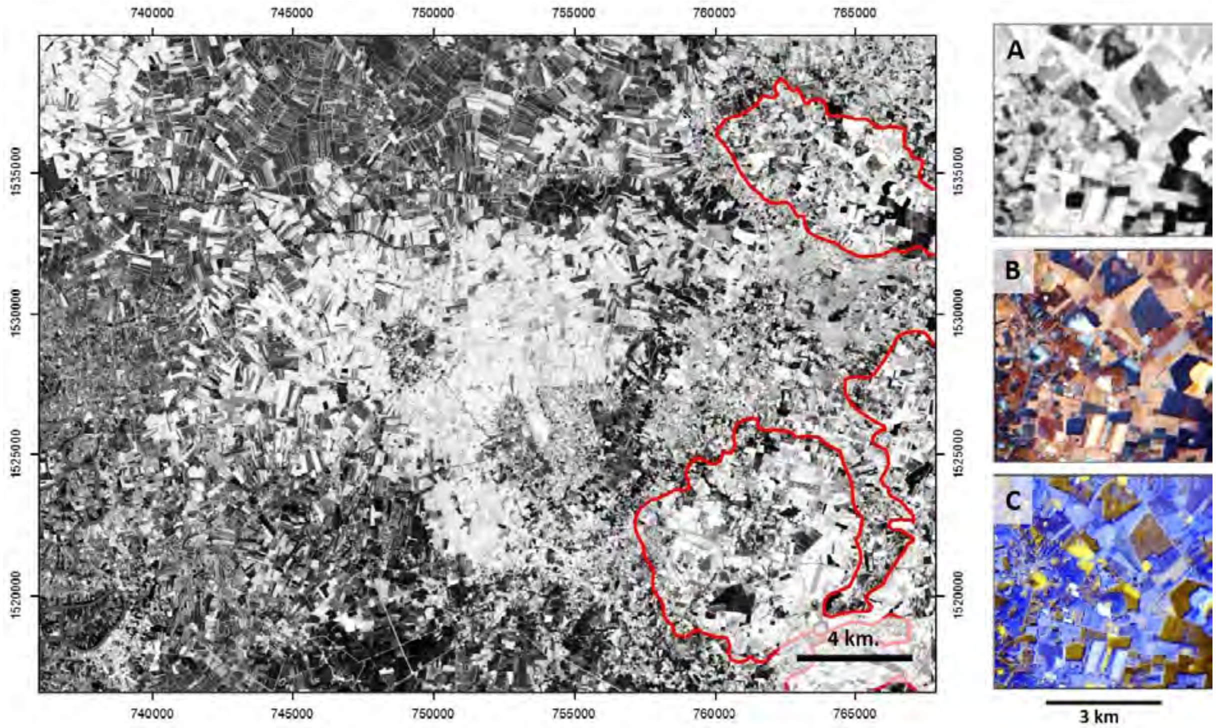

Figure 3-13 Distribution of unit A is located at the east of study area shows differenced shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

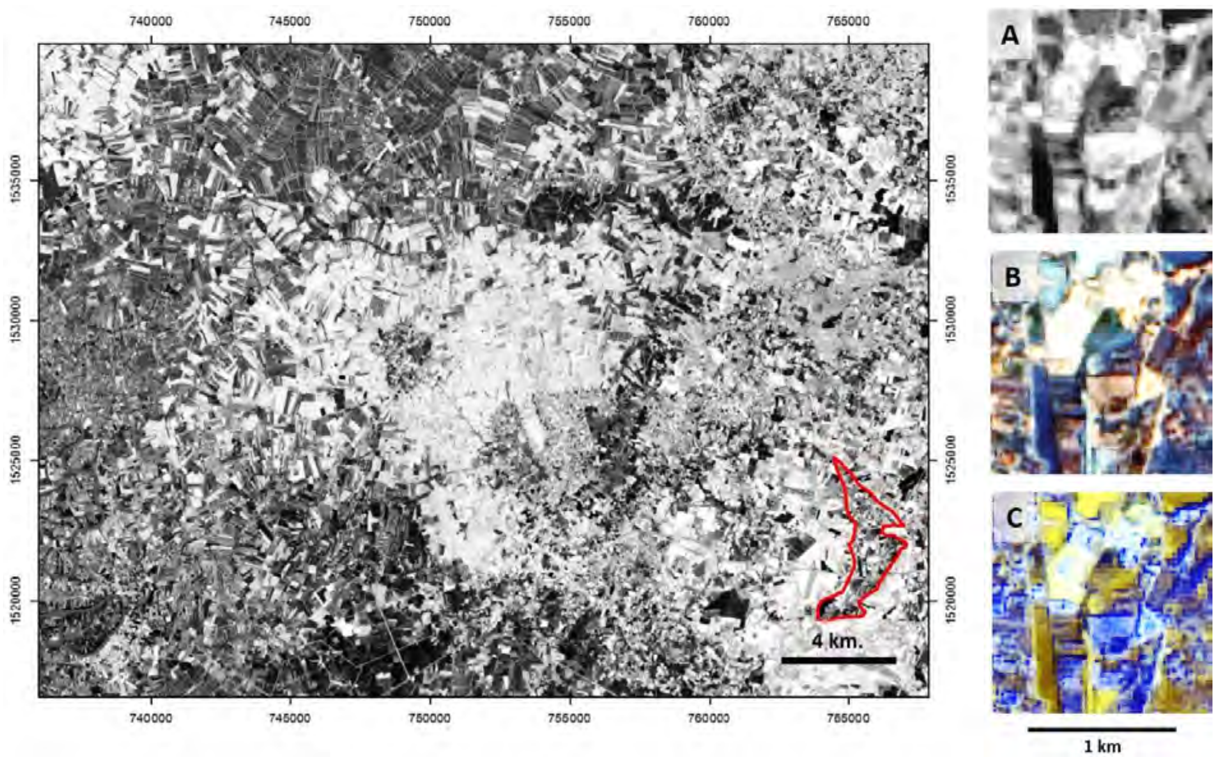

Figure 3-14 Distribution of unit B shows differences shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

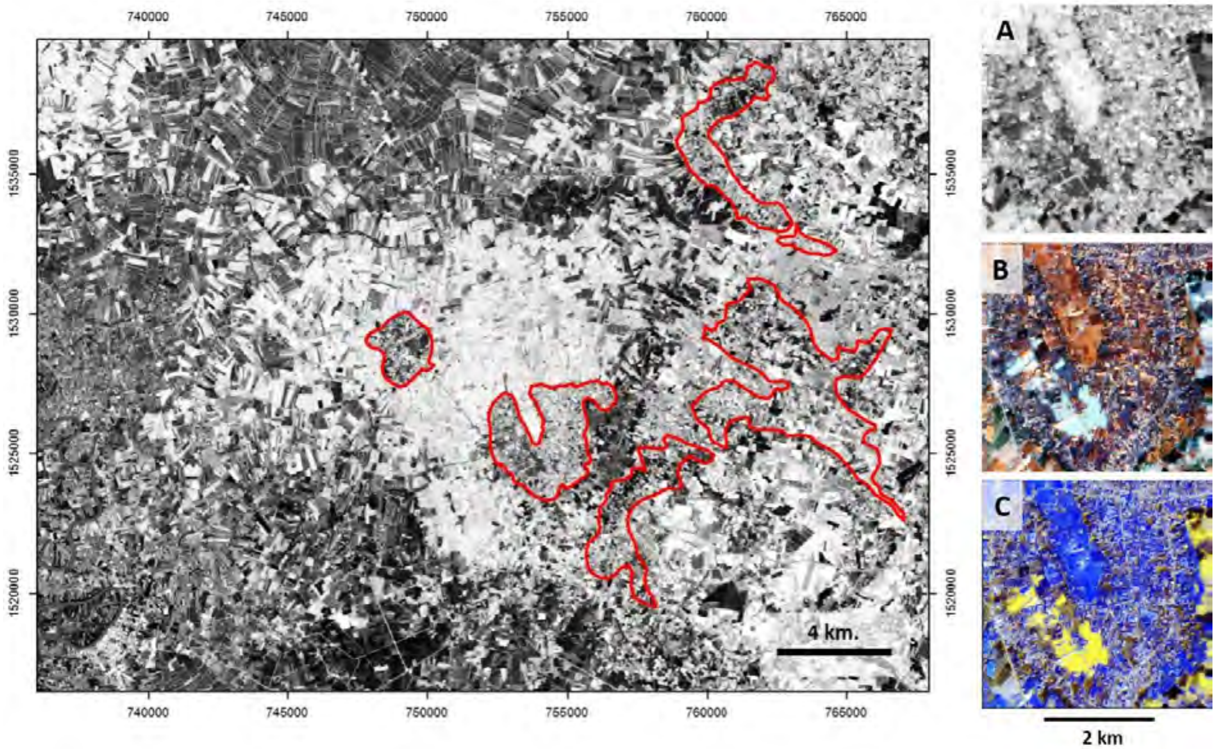

Figure 3-15 Distribution of unit C and shows differences shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

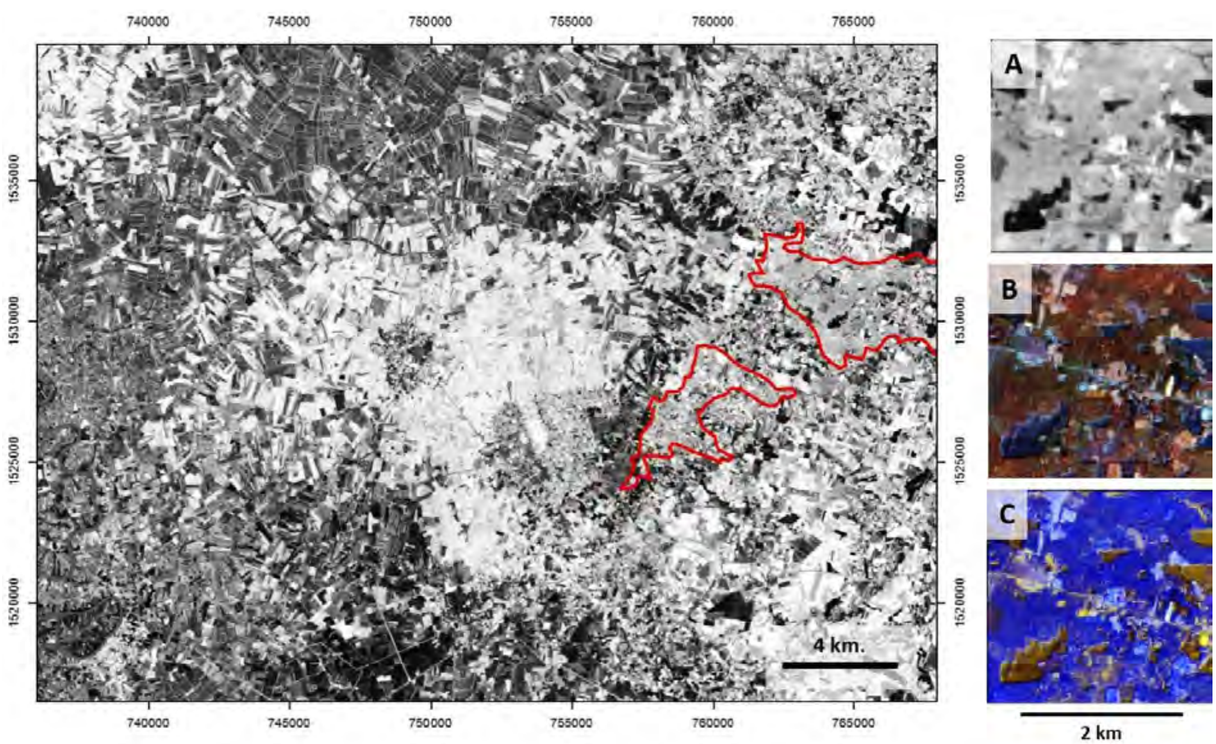

Figure 3-16 Distribution of unit D and shows differences shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

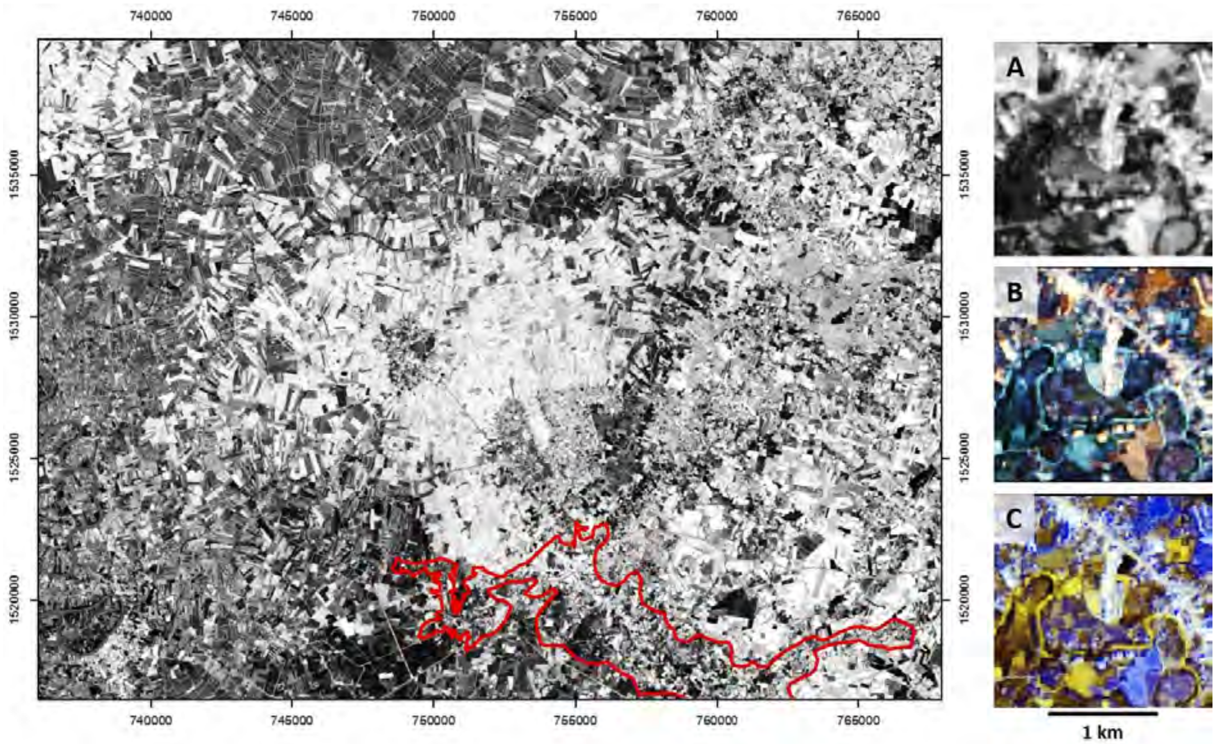

Figure 3-17 Distribution of unit E and shows differences shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

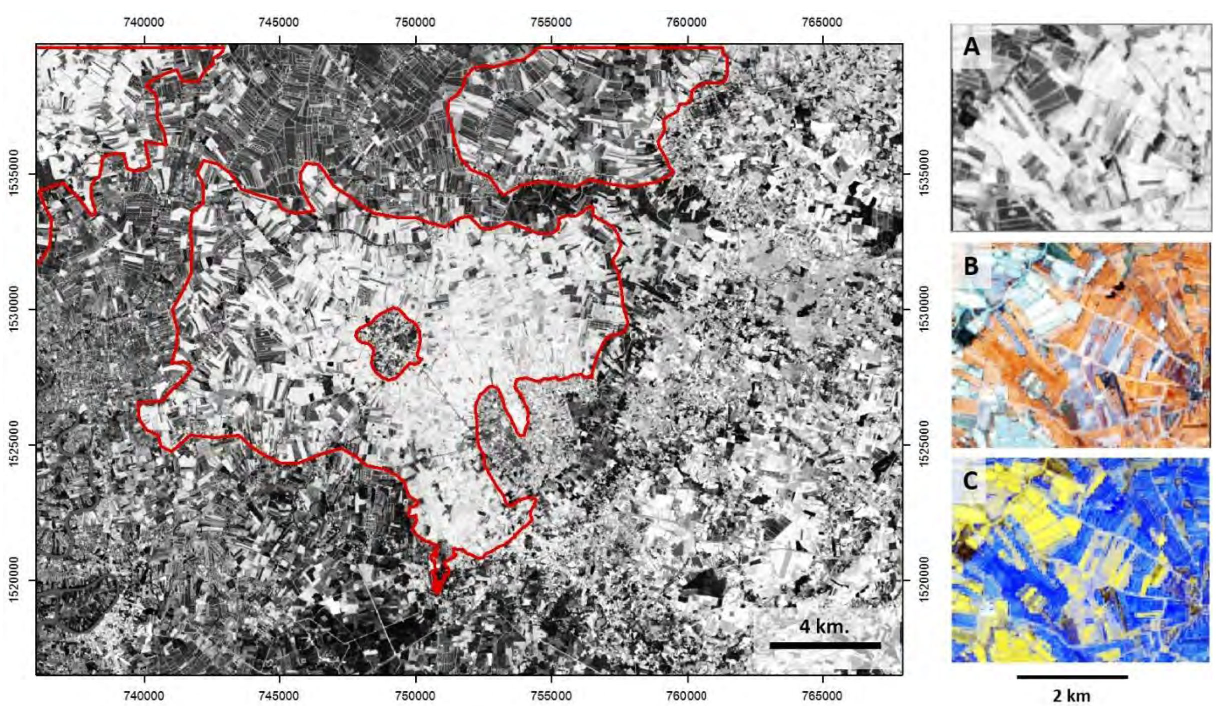

Figure 3-18 Distribution of unit F and shows differences shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

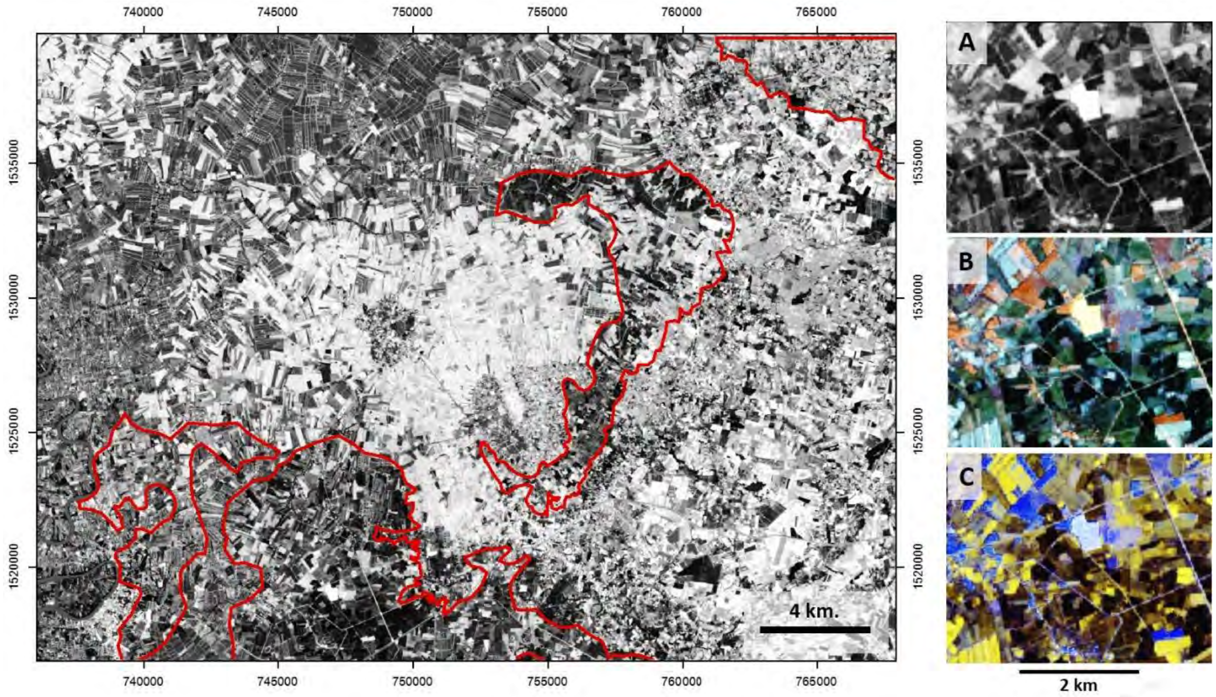

Figure 3-19 Distribution of unit G and shows differences shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

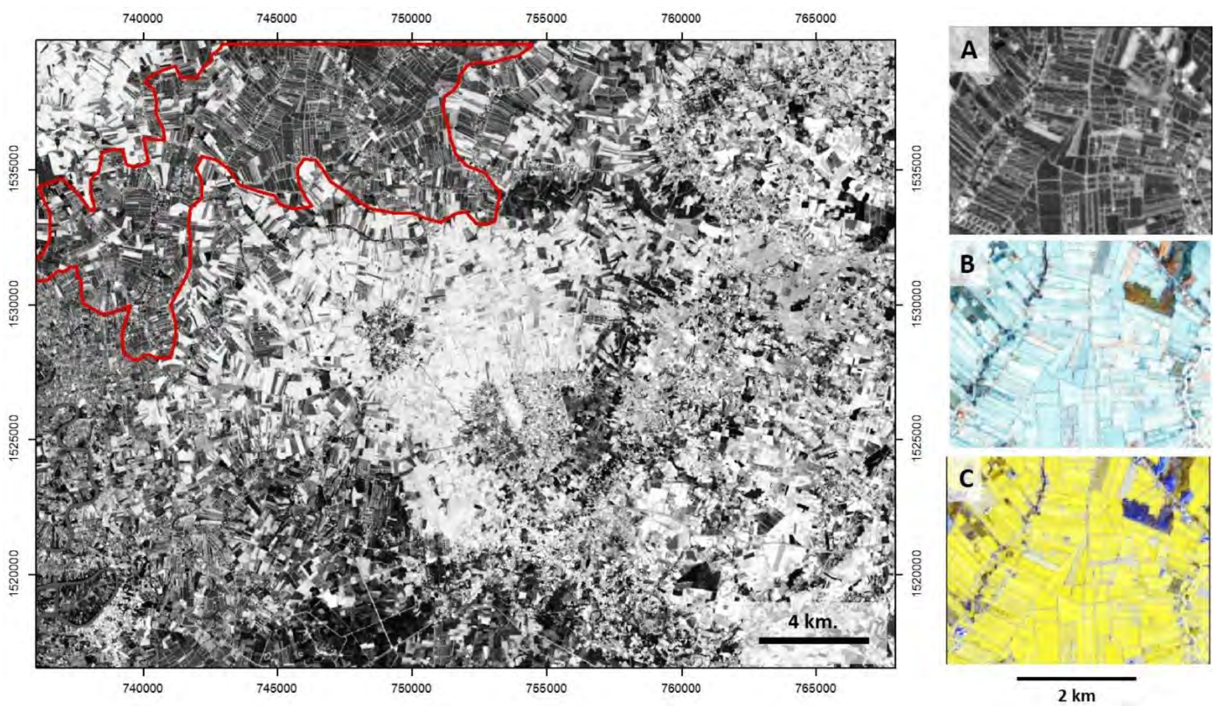

Figure 3-20 Distribution of unit H and shows differences shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

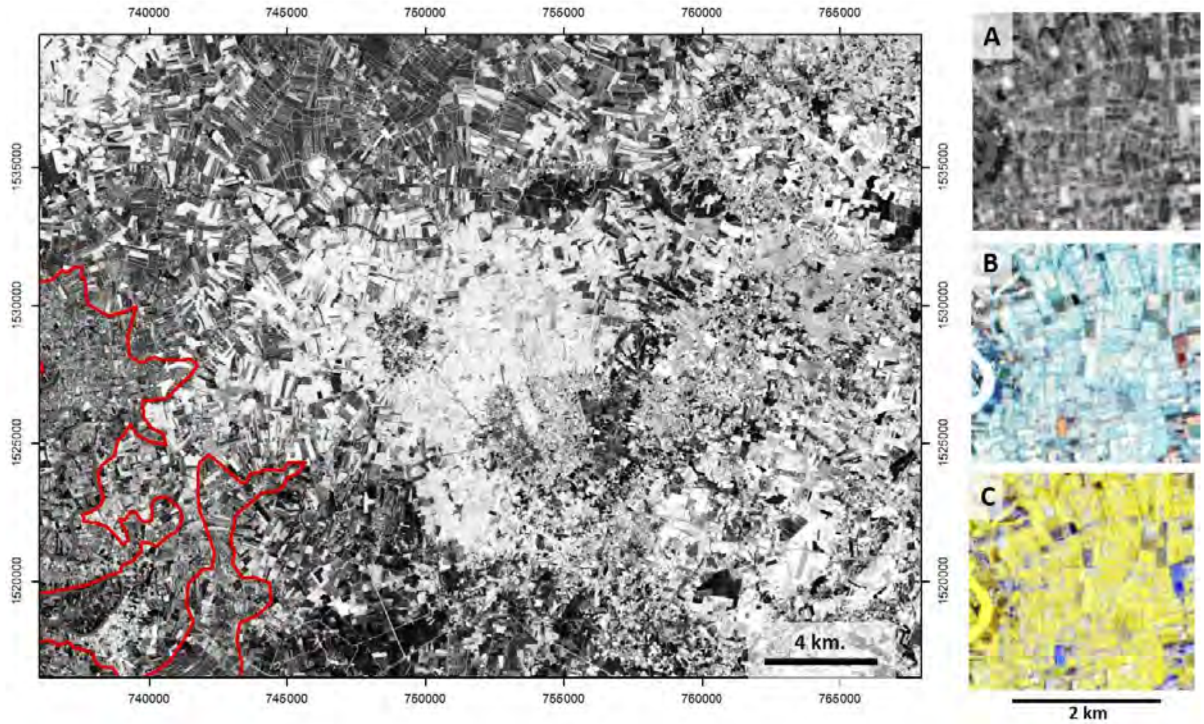

Figure 3-21 Distribution of unit I and shows differences shade and details in (A) RGB: 777 (B) RGB: 732 and (C) RGB: 127

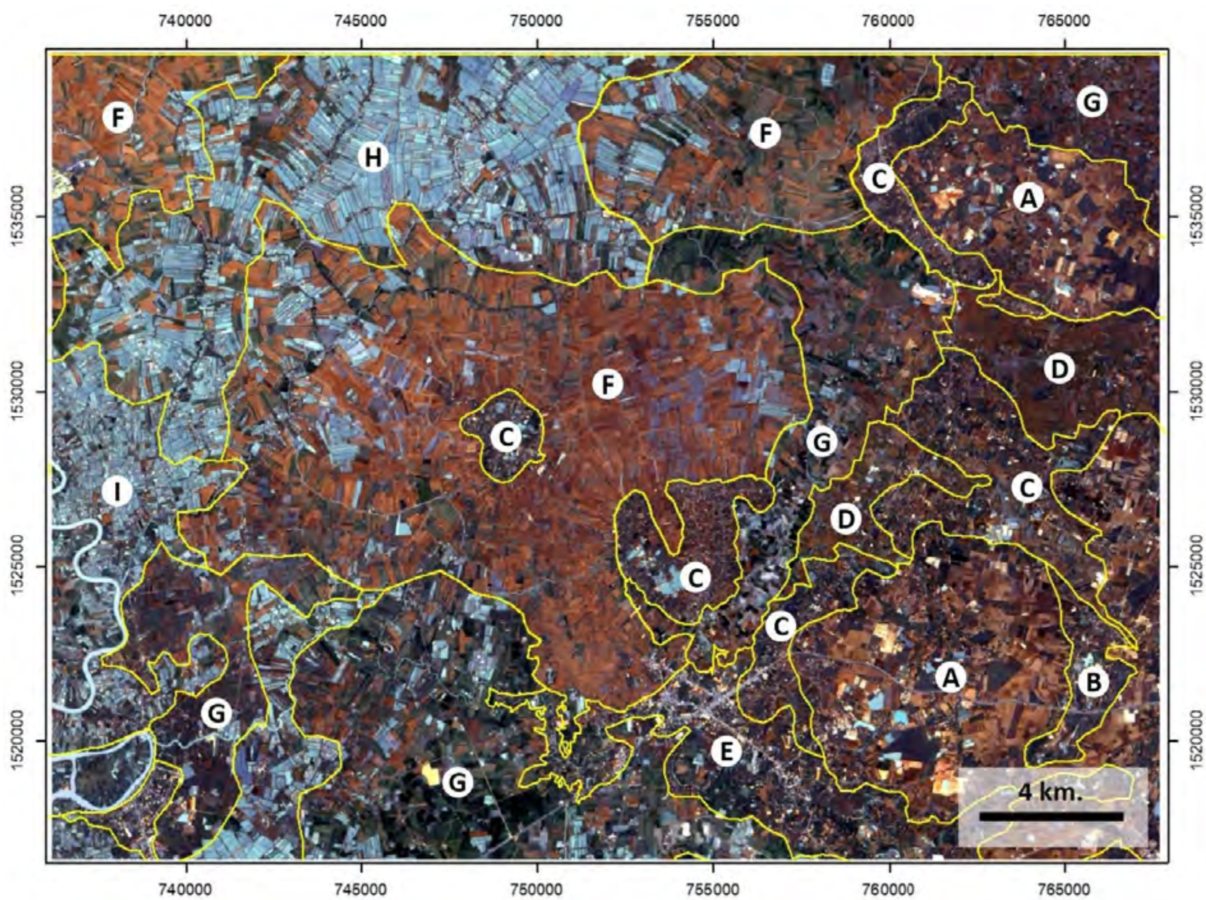

Figure 3-22 Visual classification map of study area from Landsat 8 OLI/TIRS (RGB: 432) that related to the methodology in Table 3-2.

3.3.2.2 Supervised classification

Choosing representative samples, training areas or training sites, for each units in the digital image that are classified by visual classification units are further used in supervised classification technique. User chooses at least 10 training sites per each unit. The supervised classification is derived and shows in detail as 8 surficial deposits units namely; unit A, Unit B, Unit C, Unit D, Unit E, Unit F, Unit G and Unit I (Figure 3-23).

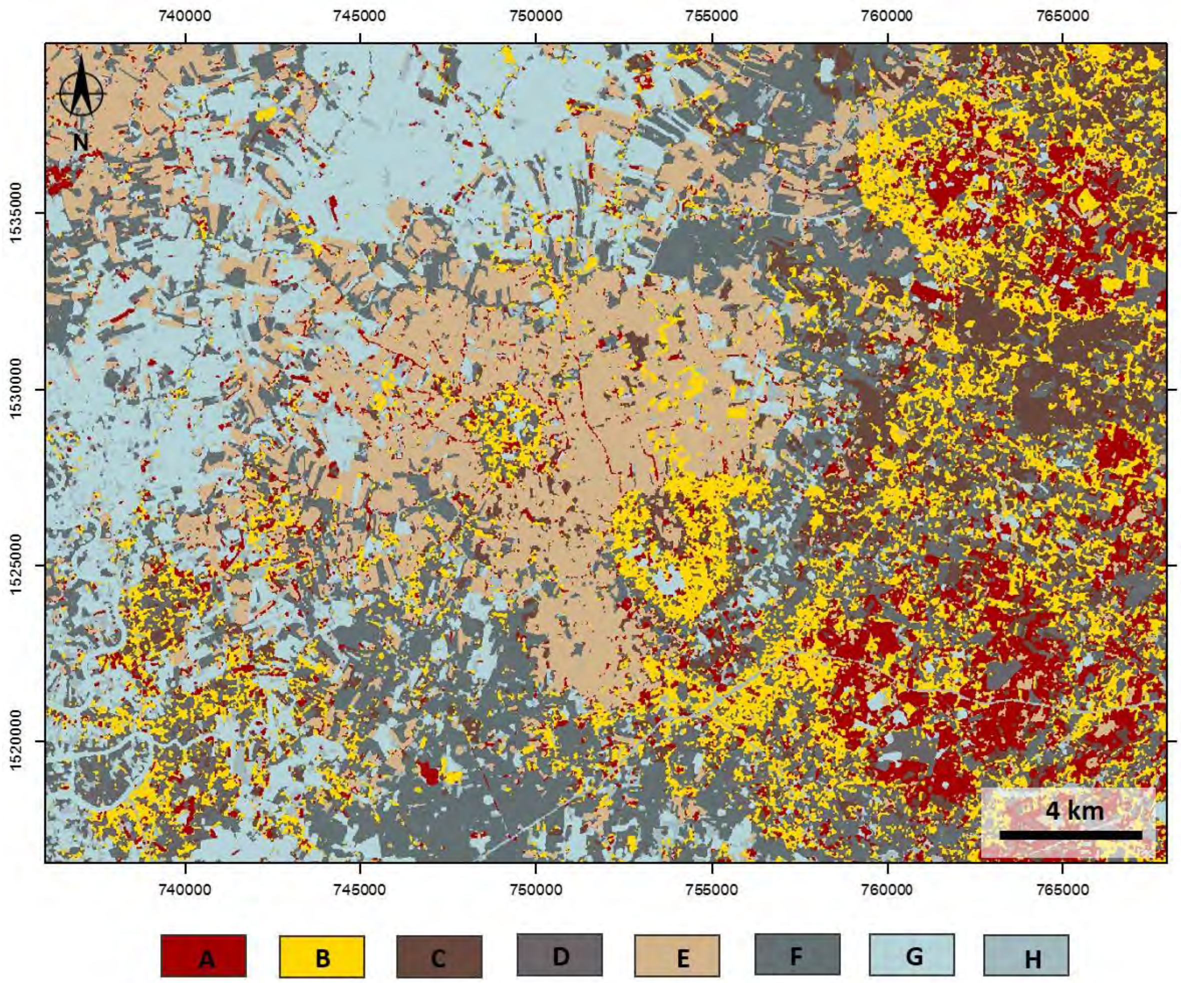

Figure 3-23 Supervised classification map of the study area

3.3.2.3 Field observation map

Field observation map (Figure 3-24) that combine the visual classification map with the Supervised classification map and Digital elevation model (DEM) and the determine surficial unit boundaries.

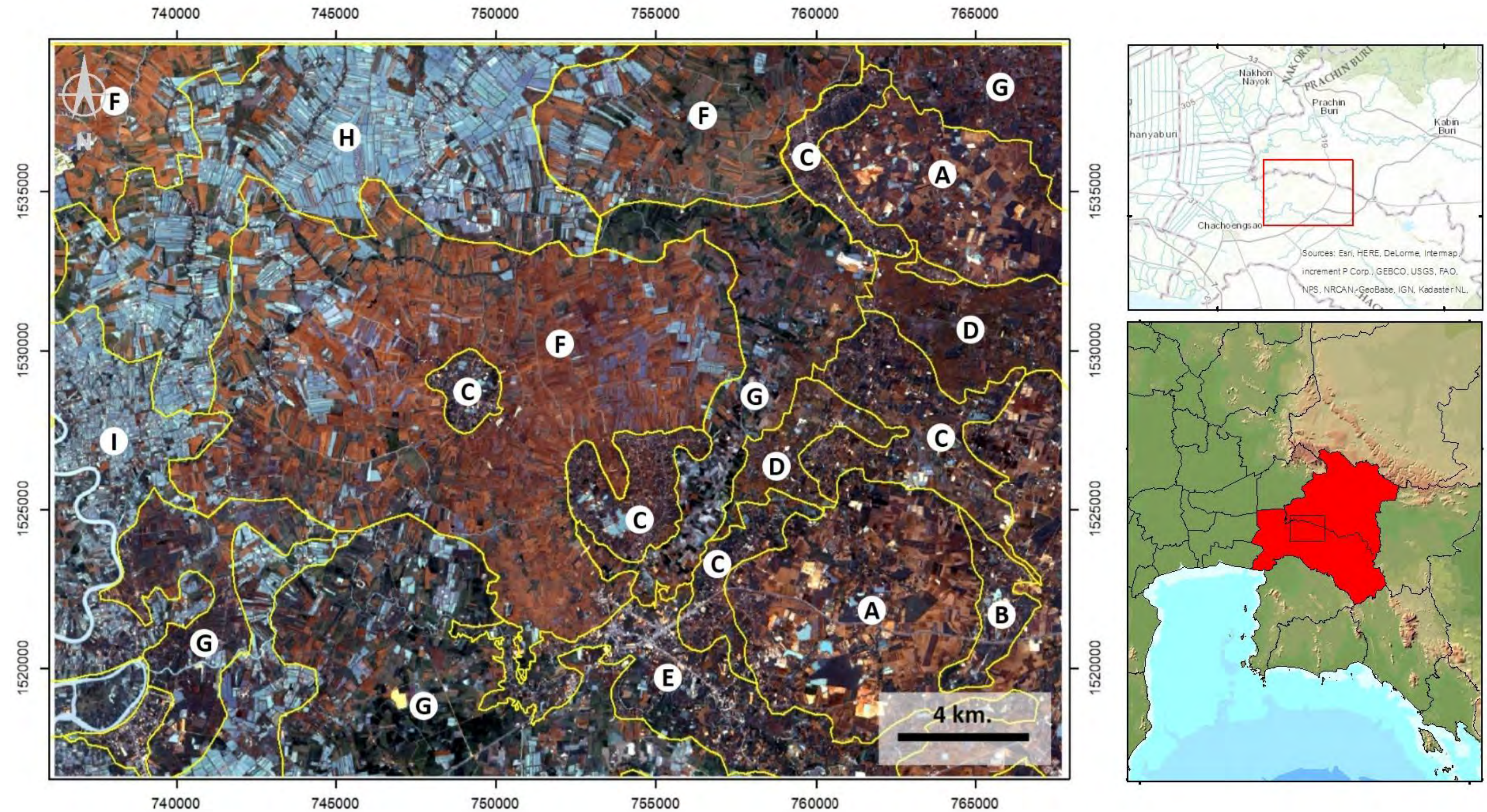

Figure 3-4 Field observation map of study area. Landsat 8 OLI/TIRS (RGB: 432)

3.4 Field observation and correction

3.4.1 Field equipment

Field preparation involves collecting of the necessary instruments. There are sample bags, Shoveling, geological hammer, compass, GPS and scales (Figure 3-25).

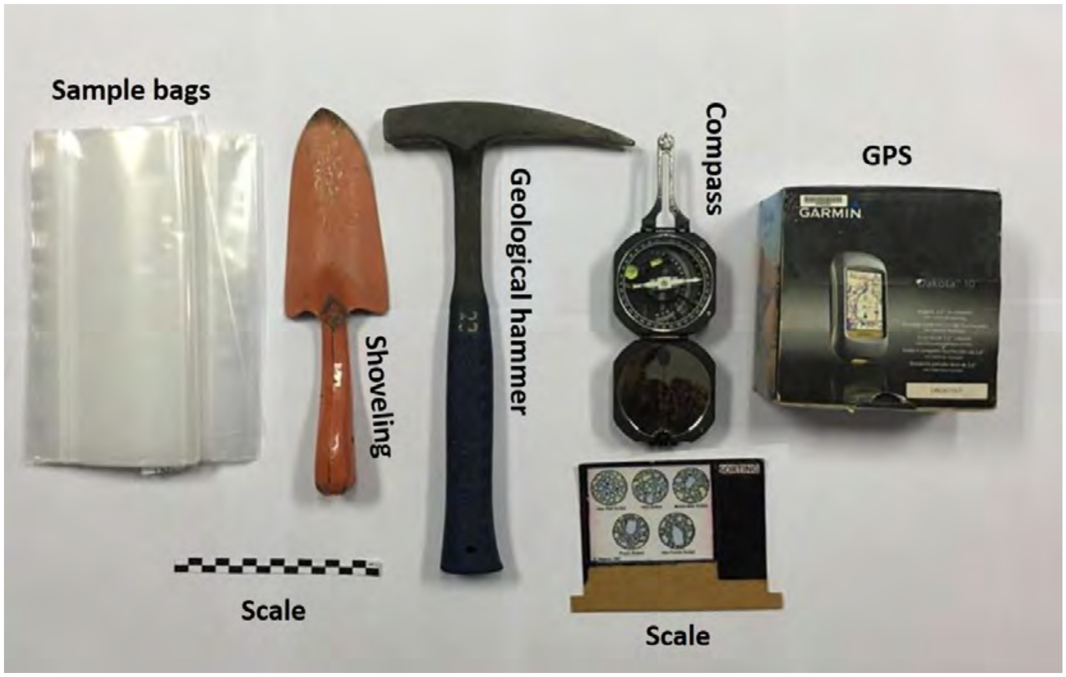

Figure 3-25 Field equipment

3.4.2 Database table design for field data

Design database is created for collect field data and is shown in figure 3-26.

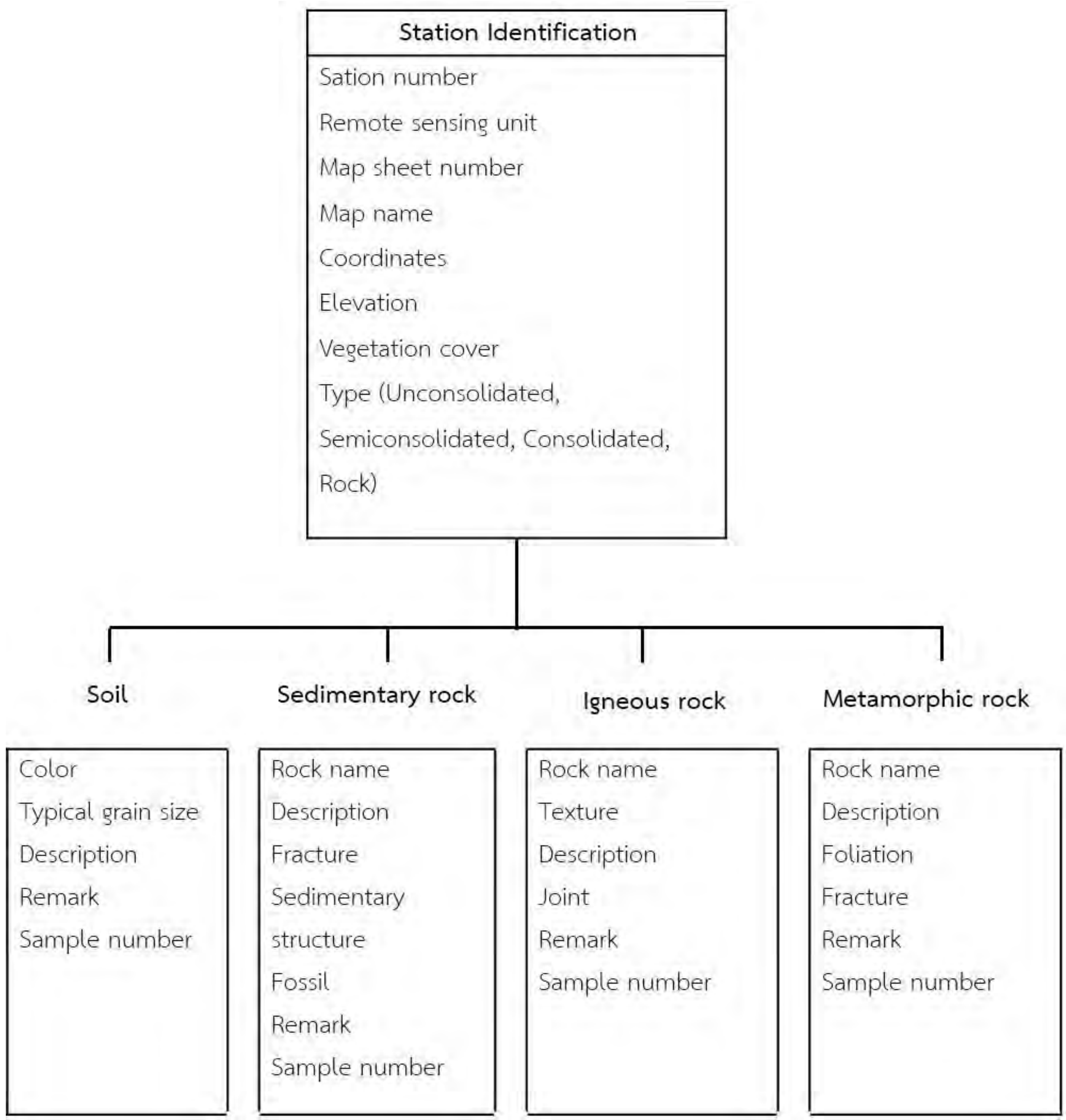

Figure 3-26 Database designed for geological field data collection

As shown in the Field observation map of study area (Figure 3-27), there are 19 stations which are observed and described the physical properties of the surficial units in the study area.

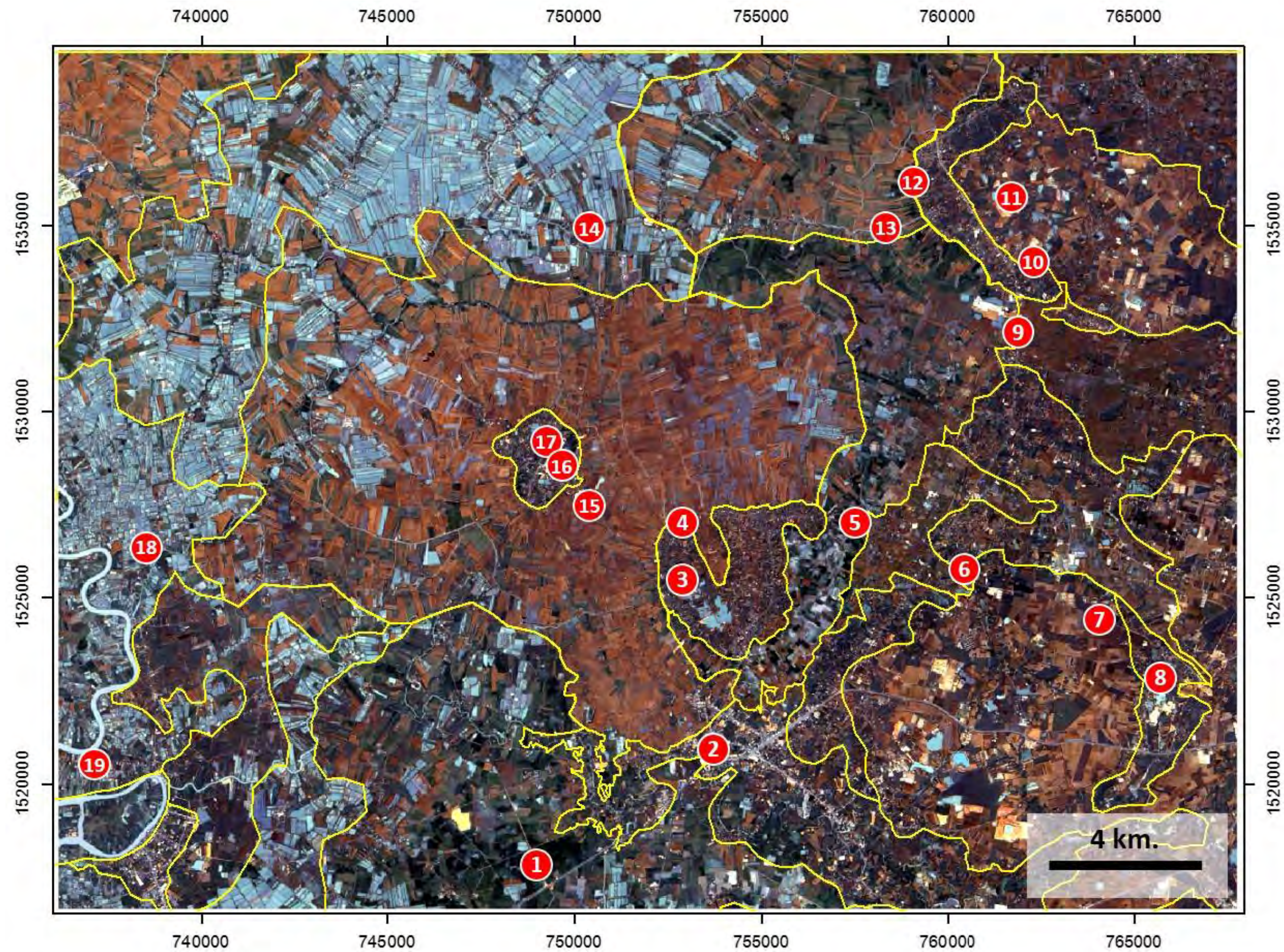

Figure 3-27 Field observation map of study area and 17 observed stations (in red circle with white number).

3.5 Analysis and Synthesis

This step is the reclassification by digital supervised method after receiving the field observation data. User chooses training sites based on the field observation data at least 10 training sites. The final result is the post-field supervised classification map that can be distinguished into 8 units following the digitally characteristics from the previous supervised map, spectral ranges and field observation data as shown as post-field supervised classification map of the study area in Figure 3-28.

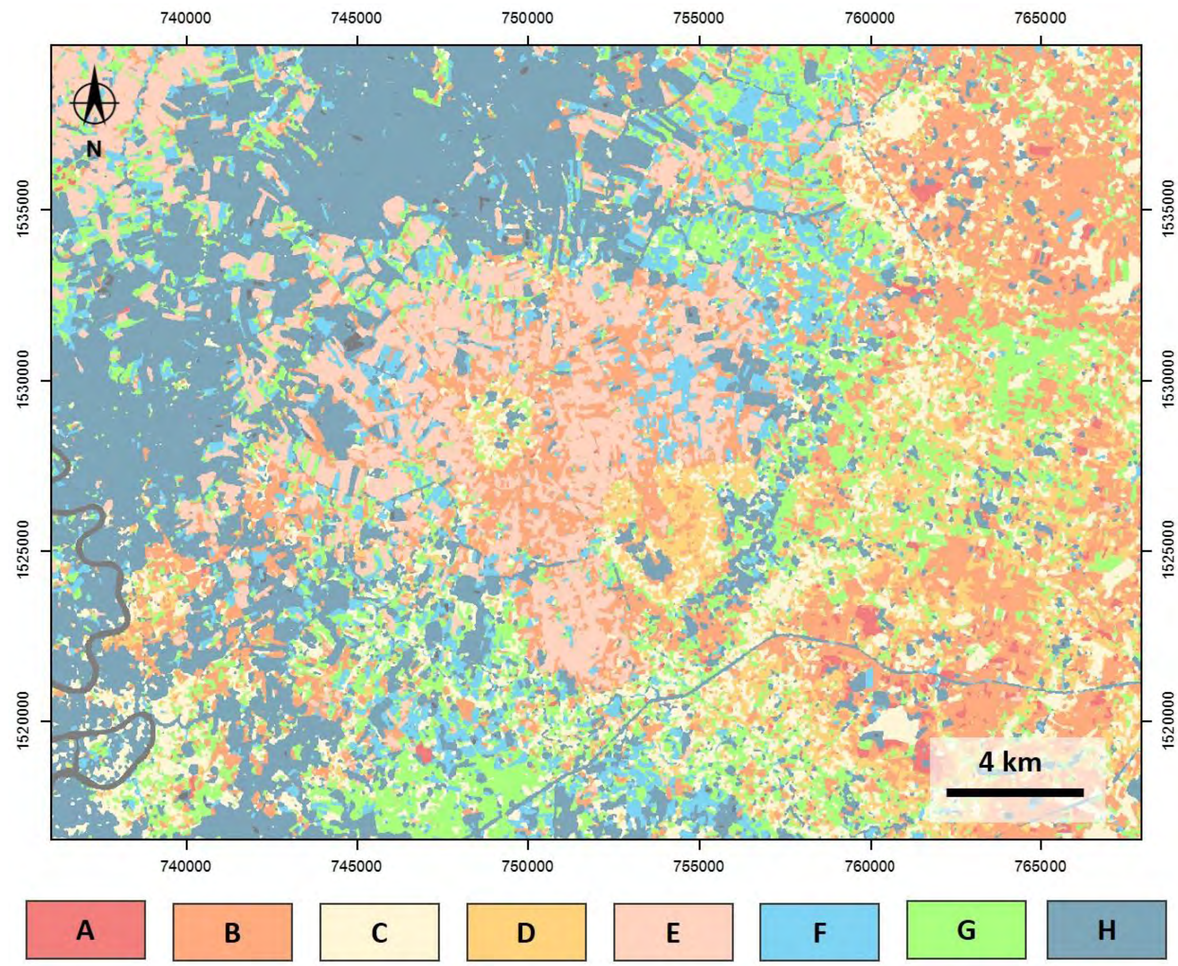

Figure 3-28 Post-field supervised classification map of study area

Chapter 4

Results

The final surficial deposits map of the study is generated by the combination of the supervised classification of Panchromatic Landsat8 OLI/TIRS imagery, field data observations and defined morphological features from 1 meters digital elevation model (DEM).

The digital mapping technique as described in Chapter 3 can divide the surficial deposits in study area into 8 Units; Unit A, Unit B, Unit C, Unit D, Unit E, Unit F, Unit G and Unit H (Figure 4-1) based on field data and supervised classification map together with DEM. Each units shows the differences of physical characteristics of surficial deposits and specific and spectral ranges from digital image. The detail of each unit is described as follow:

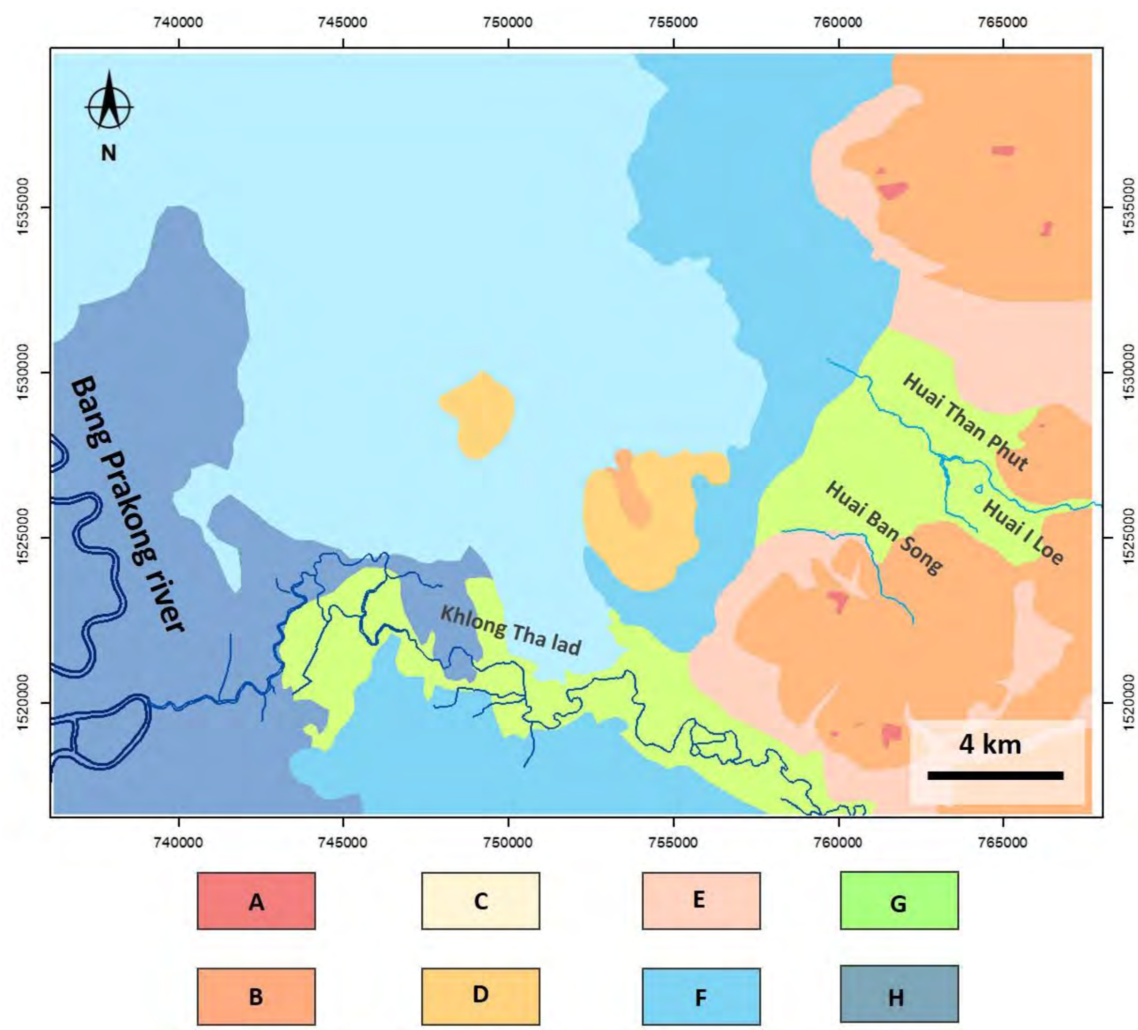

Figure 4-1 Digital surficial deposits map of study area

4.1 Unit A

The represent outcrop and characteristics of Unit A is Laterite (as shown in Figure 4-2) which overlay on bedrock (Figure 4-3).The laterite and bedrock is intruded by quartz veins. Bedrock is weathered shale which has a NW-SW bedding plane and dip direction in SW. The Spectral ranges of unit A is 251-255.

Figure 4-2 Laterite large outcrop (4x10 m. size) in the western part of the study at the field observation station 11 in Figure 3-27

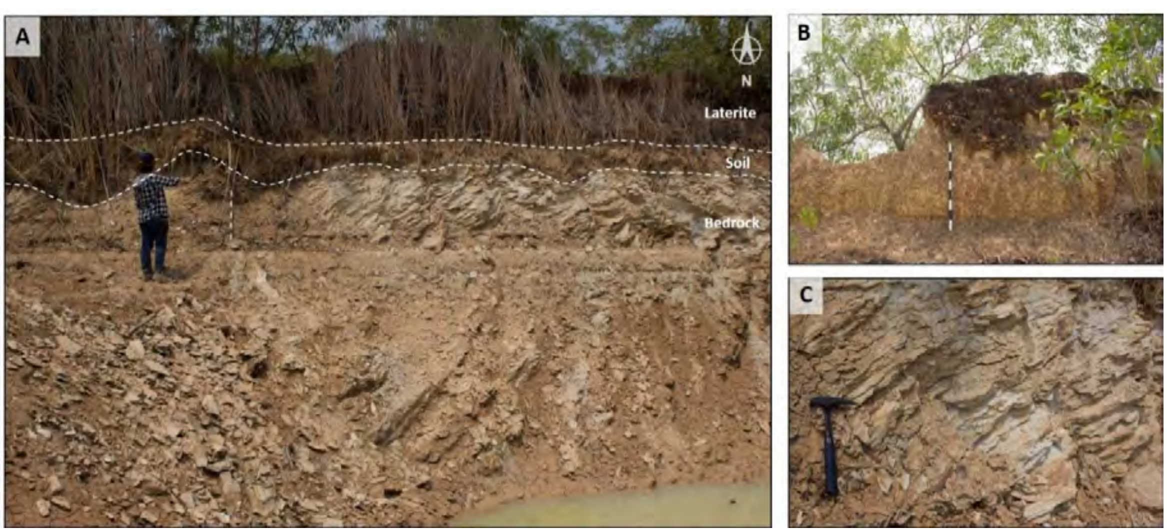

Figure 4-3 (A) The outcrop is consist of Laterite (B) that overlays on (C) weathered shale at the field observation station 11 in Figure 3-27

4.2 Unit B

The characteristics of Unit B is pale brown to brown silt to clay sediments with large amount of laterite grains and quartz grains which their diameter size is 1-3 centimeter. (As shown in Figure 4-4).This unit deposits at elevation more than 20 meters and covers unit A. The unit B is covered by cassava plant. The spectral range of unit B is 79-140.

Figure 4-4 Pale brownish to brownish silt to clay sediments with laterite grains and quartz grains at the field observation station 7 in Figure 3-27

4.3 Unit C

The characteristics of Unit C is reddish to pale brownish silt to clay sediment which overlays on laterite (Figure 4-5). This unit deposits on slope change at elevation 2-10 meters. The spectral range is 40-172.

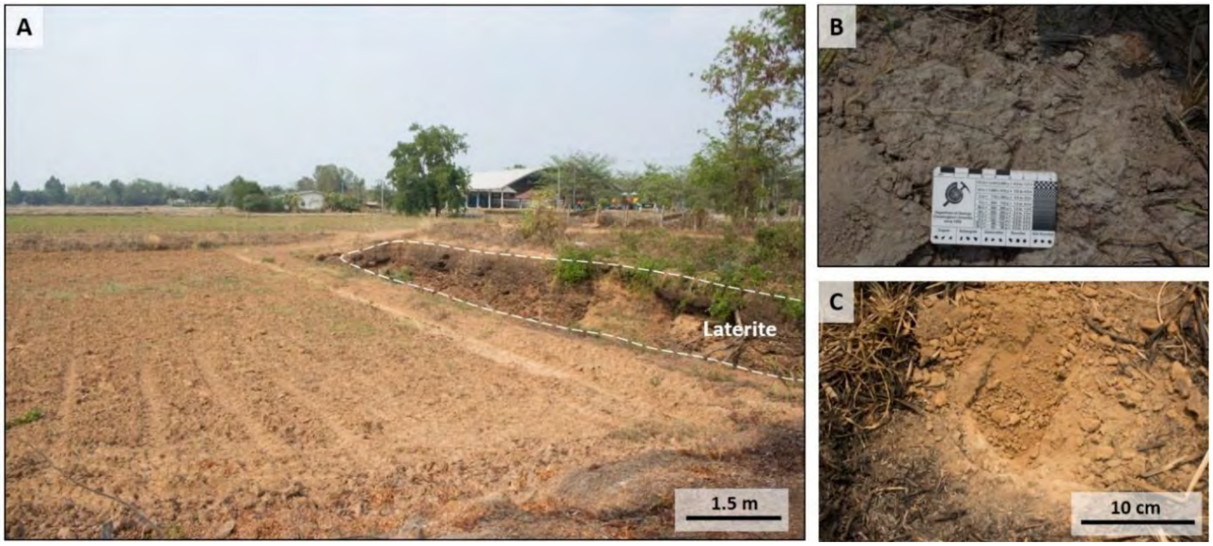

Figure 4-5 (A) Reddish to pale brownish silt to clay sediment at the field observation 12 in Figure 3-27 which overlay on laterite. (B) Pale brownish sediments and (C) reddish sediment

4.4 Unit D

Unit D is in the middle of the study area. The characteristics of Unit D are gravels to fine sand sediments (Figure 4.6). The gravels are mostly quartz that is poorly sorted and sub-angular to sub-round. The gravel size is approximately 3-7 centimeters in diameter. The spectral range of unit D is 167-193.

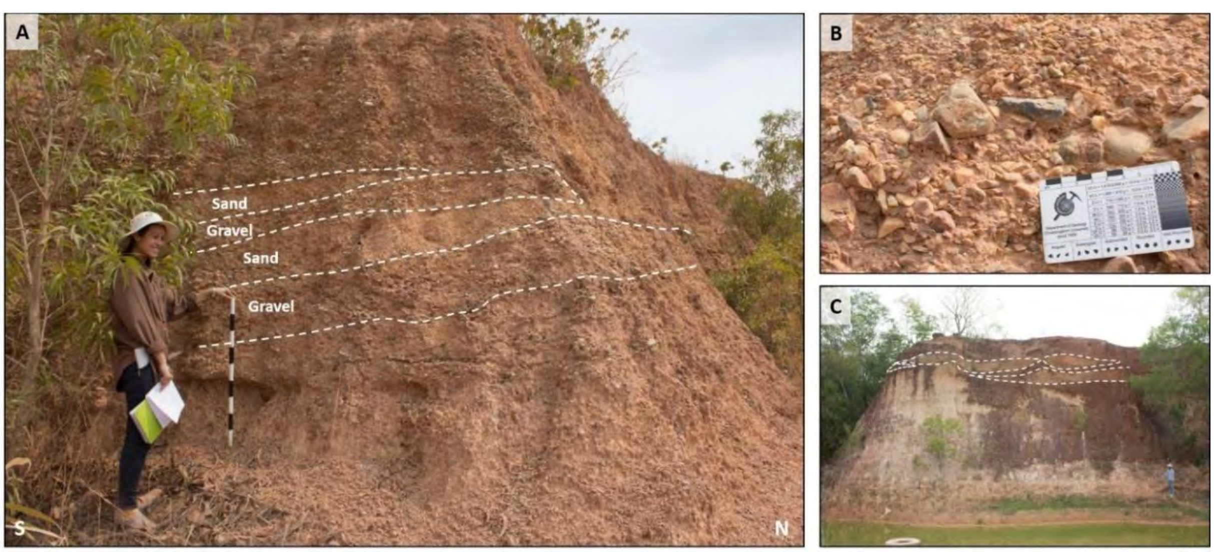

Figure 4-6 Gravel beds are interbeded with coarse sand to sand size sediments beds (A) at the field observation 3 in Figure 3-27. (B) Gravel bed and (C) package of gravel.

4.5 Unit E

The characteristics of Unit E are greyish silt to clay size sediments (Figure 4-8). The upper part of this unit is disturbed by agriculture activities (Figure 4-7). The spectral range is 224-246.

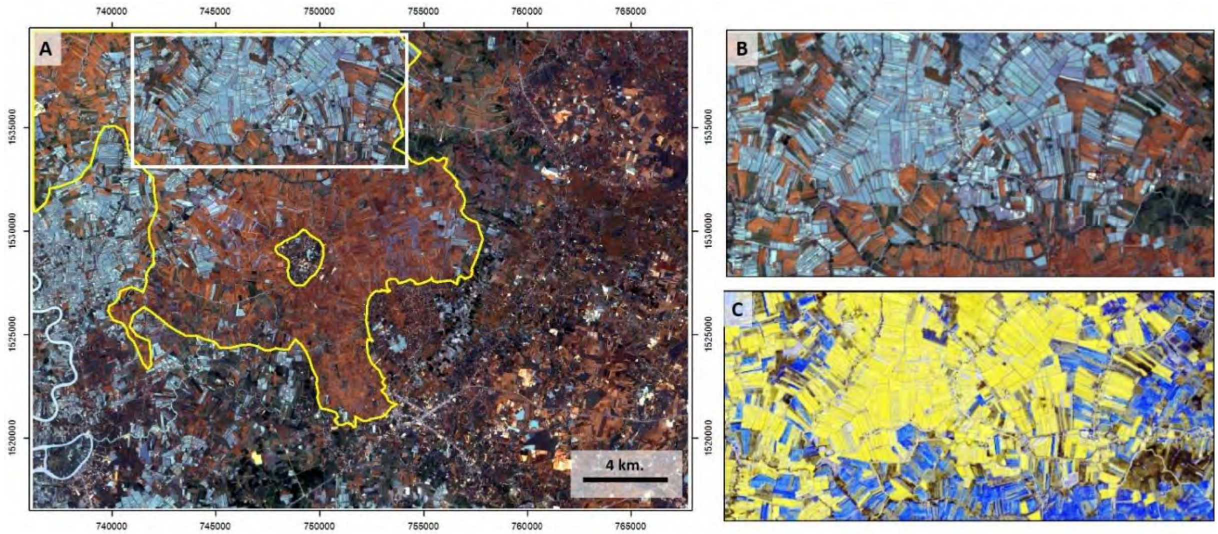

Figure 4-7 (A) The distribution of unit D and disturbed area in the upper part of unit E in white frame. (B) Disturbed area of unit E shown in Landsat 8 OLI/TIRS (RGB: 432) and (C) Disturbed area of area of unit E shown in Landsat 8 OLI/TIRS (RGB: 127)

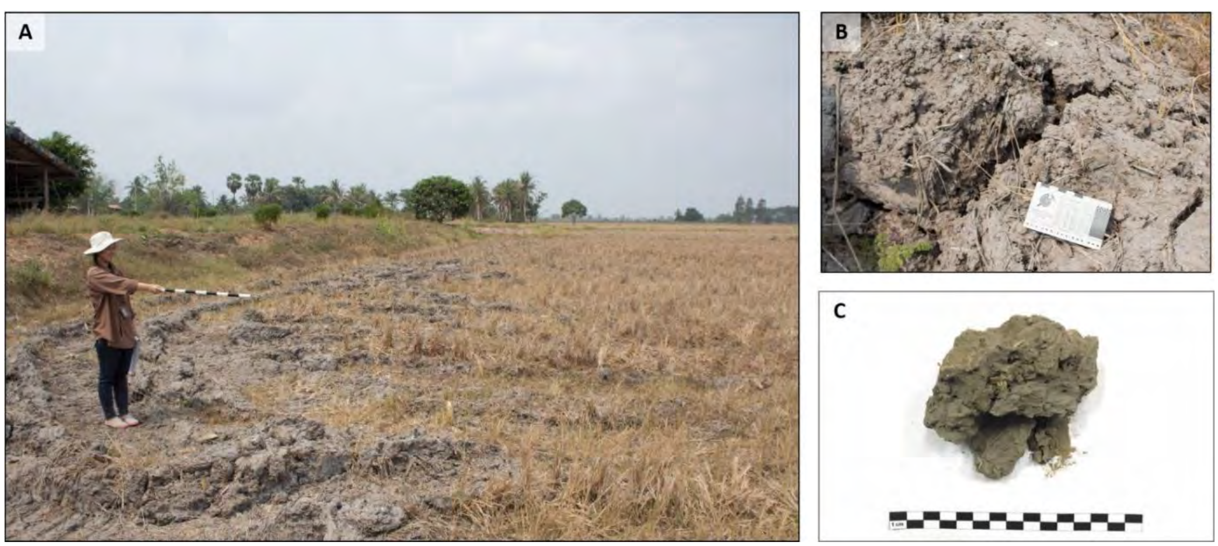

Figure 4-8 (A) Greyish silt to clay size sediment is in study area and (B) (C) Samples of Unit E at the field observation station 4 in Figure 3-27

4.6 Unit F

Unit F is located in the north part of the study area. The characteristics of unit is Dark brownish clay size sediments with laterite grains is approximately 1-2 centimeters in diameter (Figure 4-9). The spectral range of unit F is 40-103.

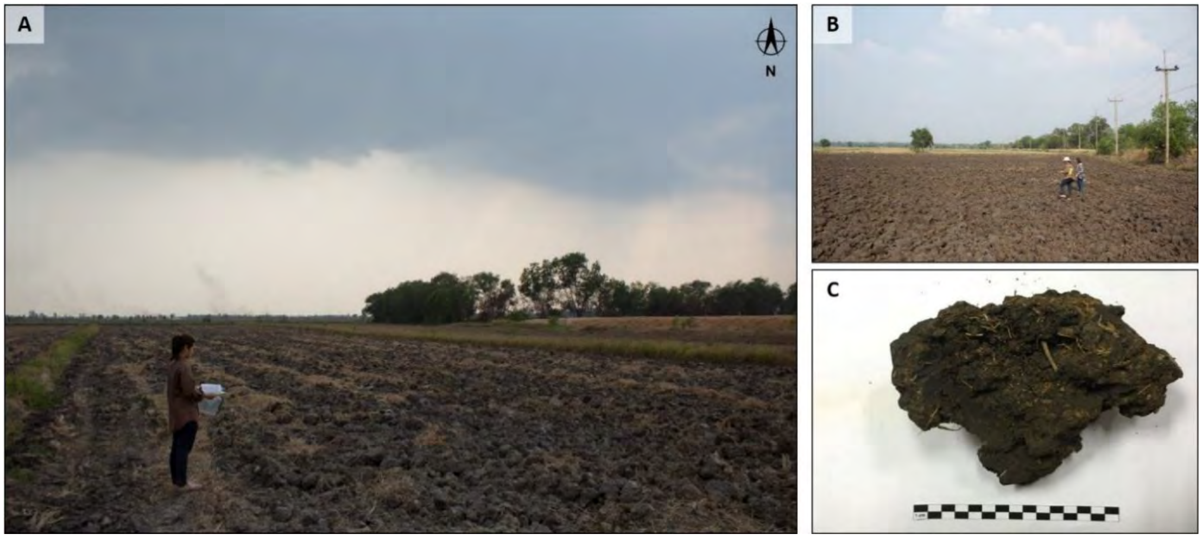

Figure 4-9 (A) (B) Dark brownish clay size sediment is in study area and (C) the representative sample of Unit F at the field observation station 13 in Figure 3-27

4.7 Unit G

The characteristics of Unit G are Light brownish very fine sand to silt size sediments with a few reddish mottling (Figure 4-10). The distribution of Unit G is along Klong Tha lad, Huai Than Phut, Huai I Loe and Huai Ban Song. The spectral range of unit is 24-79.

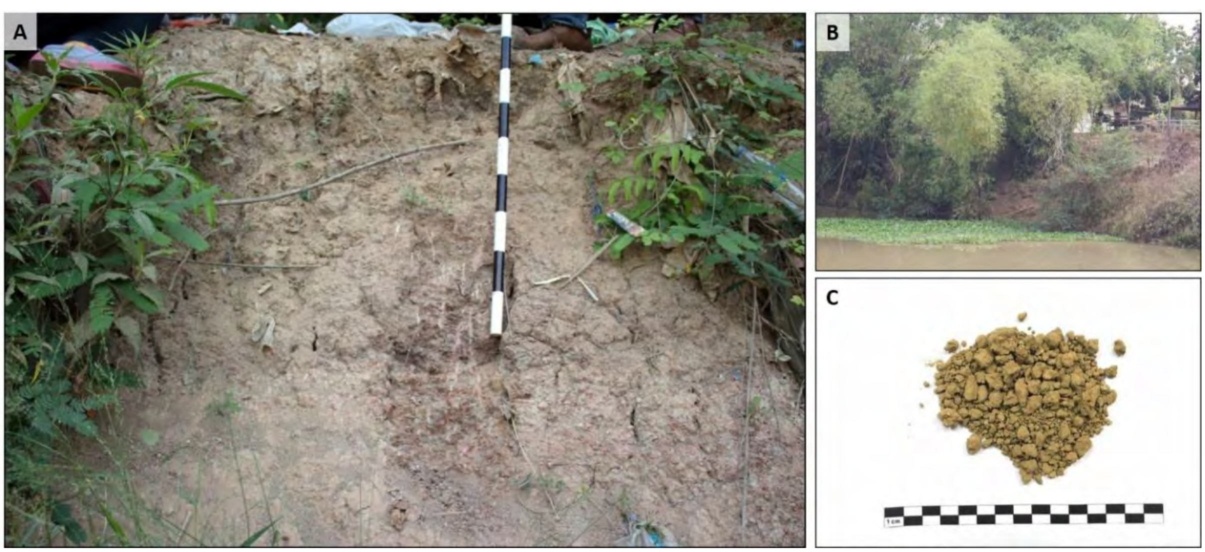

Figure 4-10 (A) Light brownish very fine sand to silt size sediments with a few reddish mottling at (B) cutbank area of Klong Tha lad and (C) the representative samples of unit at the field observation station 2 in Figure 3-27

4.8 Unit H

Unit H deposits along Bang Prakong River. The characteristics of Unit G is blackish clay (Figure 4-11). This area is horticulture and urban zone. The spectral range of unit is 65-170.

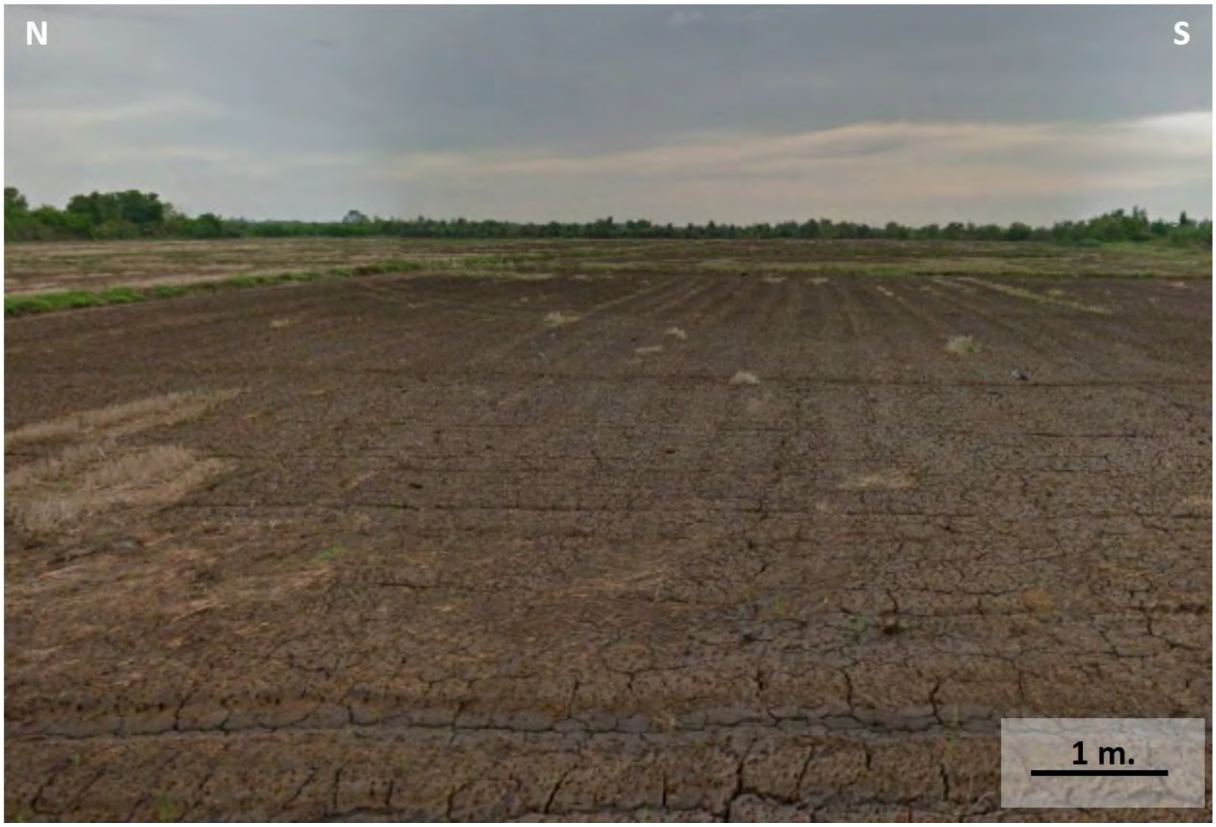

Figure 4-11 Blackish clay is in study area at the field observation station 19 in Figure 3-27

Spectral ranges were used to divide units and corresponding to each surficial deposits unit which obtained by quantitative analysis of surficial units. The several differences of spectral ranges represent the surficial map units as shown in Figure 4-12.

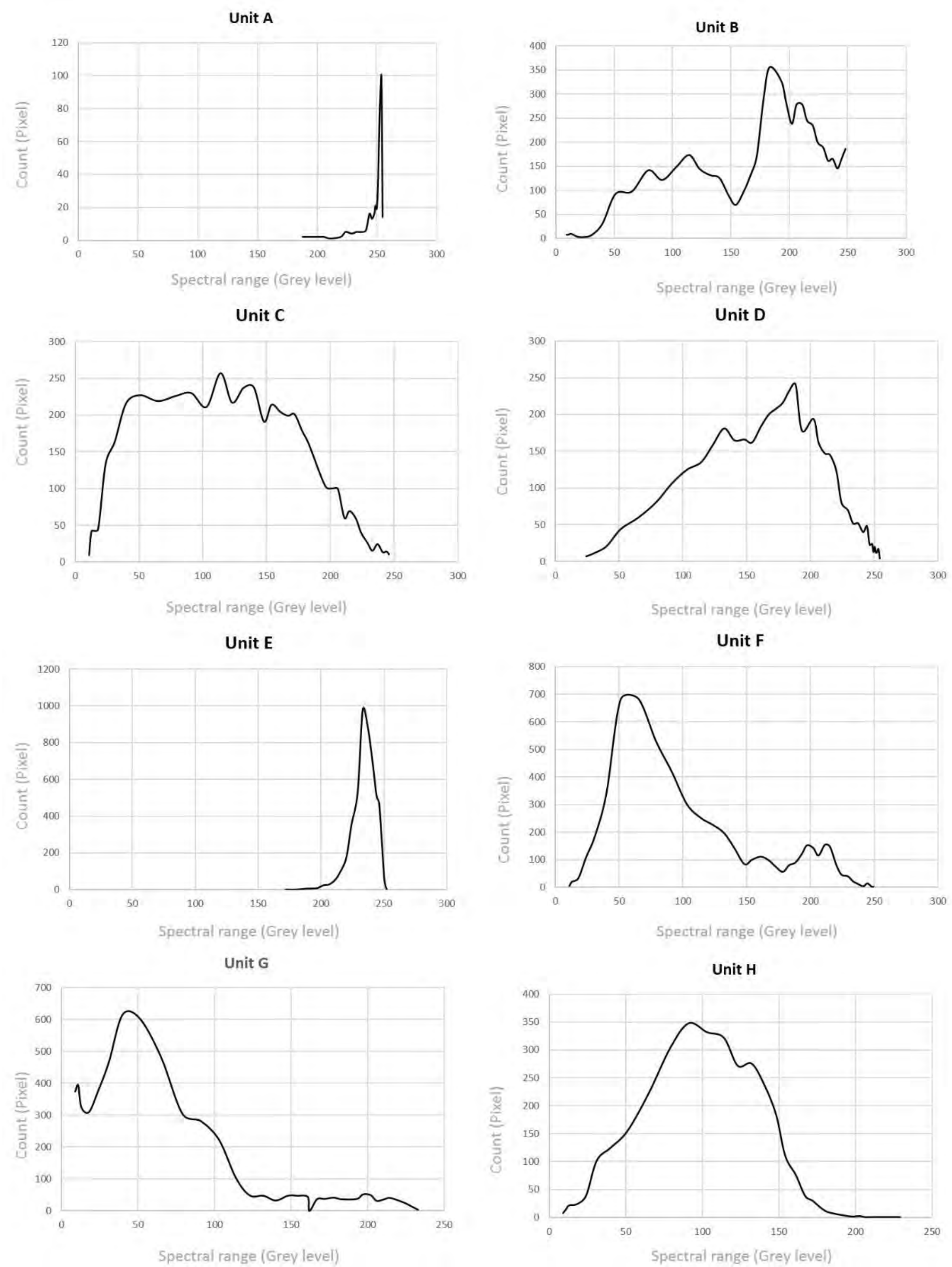

Figure 4.12 The spectral ranges of surficial deposits units, namely; A, B, C, D, E, F, G, and H

The accuracy measurement of the digital mapping using statistics based on error matrix which is a pixel which matches a ground validation (Table 4-1). The overall percentage correct of this study is 64 percent that can be calculated by the equation as follow:

The overall percentage correct = [(sum of diagonal pixels)/total pixels overlap] x100

Table 4-1 Error matrix which the diagonal pixels is shown in orangey frame

Classified data	A	B	C	D	E	F	G	H	water
A	225	466	11	15	44	0	31	10	0
B	2	5481	323	696	259	256	456	183	0
C	0	294	2743	717	0	395	1181	512	0
D	3	559	1137	2065	2	125	752	85	0
E	5	298	0	1	5023	125	19	3	0
F	0	25	195	32	0	1963	221	392	69
G	0	242	400	264	1	494	1125	265	0
H	3	40	140	51	0	2562	333	5562	49
water	0	0	0	0	0	54	4	78	2097

Chapter 5

Discussion and Conclusion

5.1 Discussion

The digital surficial deposits map from this study can be empirically compared and discussed with the surficial unit from Takaya' (1972) and the geological map scales 1:250,000 from Department of mineral resources (2007) as follow:

5.1.1 Quaternary outcrops of southern part of the central plain of Thailand (Takaya, 1972)

This study is described 60 representative core samples of Quaternary outcrops of southern part of the central plain of Thailand. The length of core samples is up to 1.5 meters. There are 4 core samples located in Si Mahosot area which are Loc 159, Loc 160, Loc 161 and Loc 162.

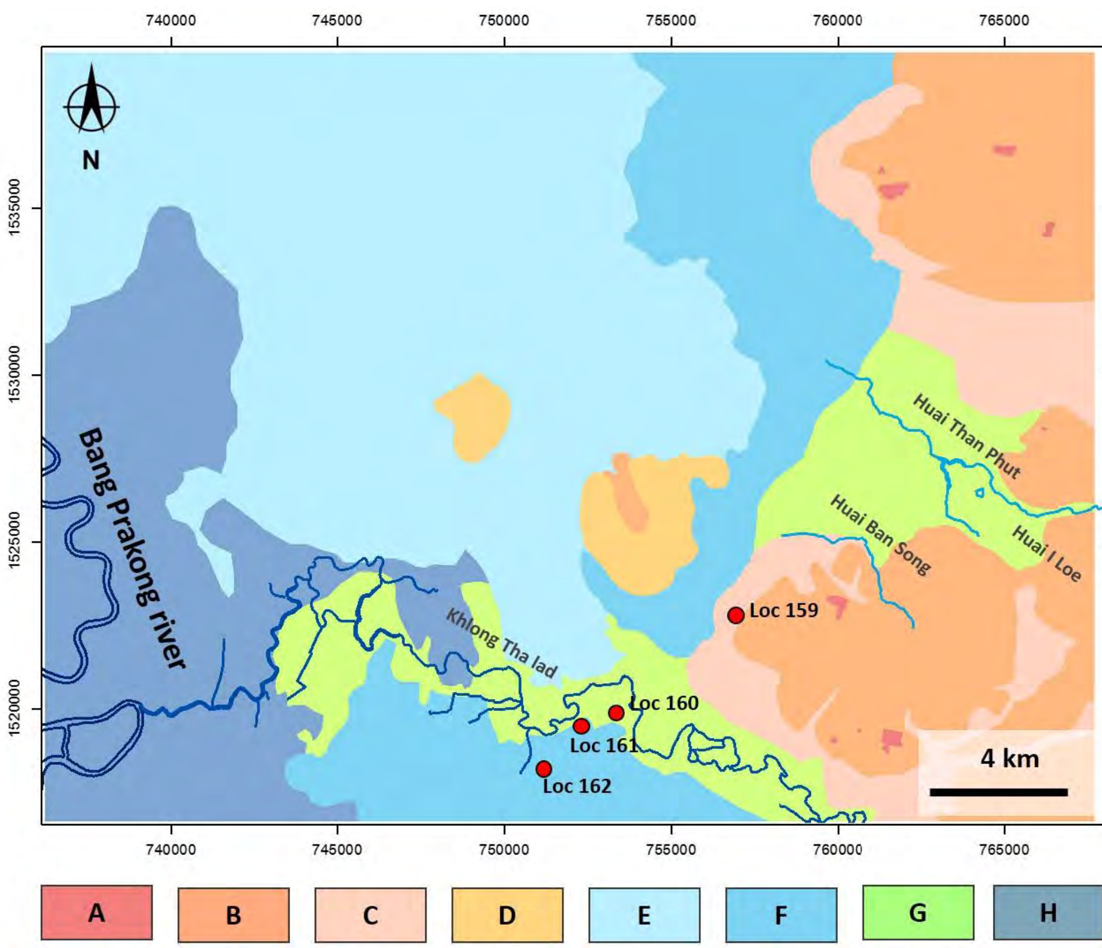

Figure 5-1 Digital surficial deposits map of this study of Si Mahosot and the core sample positions from the study of Takaya (1972)

Table 5-1 Comparison between core sample from the study of Takaya, 1972 (as shown in Figure 5-1) and the observed Stations from this study (as shown in Figure 3-26)

<table>
<tr><th>Tayaka, 1972</th><th>The study of Si Mahosot area</th></tr>
<tr><td>Loc 159 – is located in unit B
From surface to 0.6 meters depth is very pale brown clay with common many quartz grains</td><td>The observed Unit B, Station 7
Pale brown to brown silt to clay sediment with many laterite grains and Quartz grains which are 1-3 centimeters size.</td></tr>
<tr><td>Loc 160 – is located in unit G
From surface to 0.3 meters depth is white sand to loam, the fertile soil of clay and sand containing humus, with many lateritic fragment</td><td rowspan="2">The observed Unit G, Station 2
Light brownish very fine sand to silt size sediment with few reddish mottling.</td></tr>
<tr><td>Loc 161 – is located in unit G
From surface to 0.1 meter depth is light olive brownish Silt, Clay and Loam with few red to yellow fibrous mottling.</td></tr>
<tr><td>Loc 162 – is located in unit F
Surficial deposit is light brownish loam and clay sediment.</td><td>The observed Unit F, Station 1 and 5
Dark brownish clay size sediment with lateritic grains around 5-10 percent. The size of grains is approximately 1-2 centimeters.</td></tr>
</table>

5.1.2 The geological map (DMR, 2007)

This digital mapping technique from this study performed excellently for distinguishing the surficial deposits units. This technique can differentiate and classify the the surficial deposits units of the study area into 8 units (A,B,C,D,E,F,G and H) whereas the geological map of DMR., 2007 has been classified into 4 units (Bedrock (DC and Trpn), Qt, Qa and Qmc as shown in Figure 5-2 and Figure 5-3.

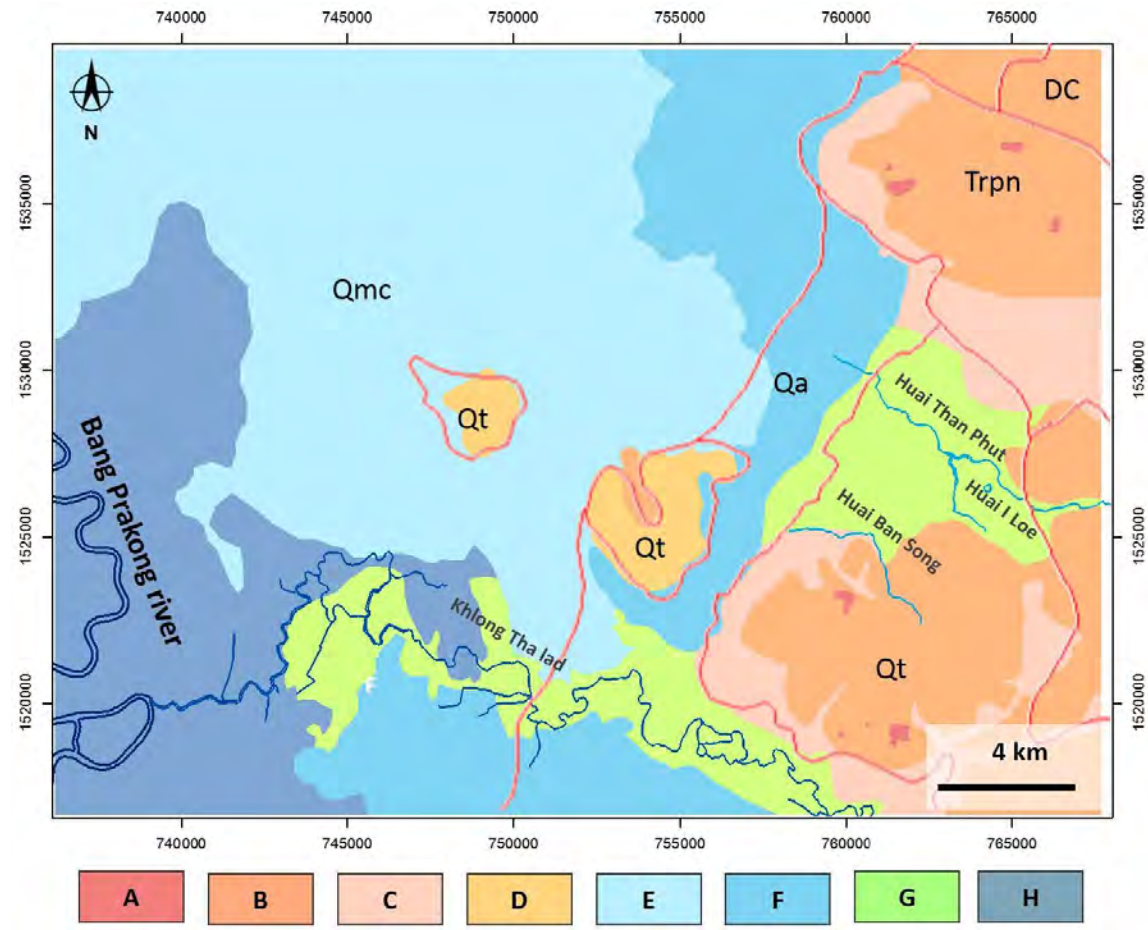

Figure 5-2 The digital surficial map is overlain by DMR's unit boundaries (in red line)

Table 5-2 Comparison between geological units of DMR (2007) and digital surficial units from this study

DMR (2007)	The study of Si Mahosot area
Bedrock – DC unit and Trpn unit DC unit is chert, tuff, limestone, and volcanics, mostly metamorphosed. Trpn unit is Greywacke, shale, limestone, and conglomerate.	Bedrock is cover by Unit A, Unit B and Unit C as follow: Unit A is Laterite Unit B is pale brown to brown silt to clay sediment with many laterite grains and Quartz grains Unit C is reddish to pale brownish silt to clay sediment
Qt – Terrace deposits Gravel, sand, silt, clay and laterites	Can defined unit boundaries which are unit A, Unit B, Unit C and Unit D as follow : Unit A is Laterite Unit B is pale brown to brown silt to clay sediment with many laterite grains and Quartz grains Unit C is reddish to pale brownish silt to clay sediment Unit D is gravel to fine sand sediment
Qa- Fluvial deposits Gravel, sand, silt, and clay of channel, river bank, and flood basin.	Unit F is Dark brownish clay size sediment with laterite grains
Qmc- Coastal-tide dominated deposits Clay, silt, and fine-grained sand of tidal flat, marsh, mangrove swamp and estuary.	Subdivided into 2 units which are unit E and unit H as follow : Unit E is Greyish silt to clay size sediment Unit H is blackish clay sediment

5.2 Conclusion

This study suggest the technique which can reliable map the surficial deposits at a regional scales. In the traditional mapping or analog mapping is defined the unit boundaries by aerial photo characteristics. The variation of mapping can be improved by changing photo scales, quality of photo, and interpretation from each person ability.

The digital method is suited for surficial mapping in area which less disturbed by human. On the other hands the variation of land use is depended on surficial deposits.

The surficial units and geomorphology of Si Mahosot area is distinctive to use digital elevation and digital image to distinguish their characteristics. Thus, this method still require more field observations and comprehend the geomorphic feature in the area.

The results of digital surficial deposits units by using the digital method which are generated from Remote sensing and digital elevation model data can be portioned out to the different digitally characteristics into 8 units classified by their properties in digital image, spectral ranged and field observation data. There are Unit A that is laterite, Unit B that is silt to clay sediment with laterite grains and quartz grain, Unit C is reddish silt to clay sediment that overlays on laterite, Unit D is gravel to fined grain sediment, Unit E is greyish silt to clay sediment, Unit F is dark brownish clay with lateritic grain, Unit G is Light brownish very fine sand to silt sediment and Unit H is blackish clay.

The three-dimensional model (Figure 5-3) shows surficial units and elevation (from Mean Sea Level, MSL) which are related to their depositional and geomorphological characteristics. As shown in Figure 5-4, the digital surficial deposits map of Si Mahosot area with the cross section-line from A-A’, in the elevation more than 20 meters (from MSL) is laterite deposits that are covered by gravel and silt to clay sediments; unit B and Unit C that are terrace deposits. At the slope change in elevation 2-10 meters (from MSL) is covered by reddish silt to clay sediments from weathered laterite. In elevation less than 2 meters (from MSL) that is the deposit of fine grain to clay sediments from fluvial and flood plain deposits; Unit E, Unit F and Unit H. For Unit G which are very fine sand to silt sediments are occurred along khlong and huai that flow toward the flood plain.

The summarize digitally characteristics and physical properties of surficial deposits units of Si Mahosot area that verified by digital method. This table is compare geological unit from Department of mineral resources (2007), surficial deposits core sample from Takaya (1972) and surficial deposits from this study. The classification is based on satellite image, Landsat 8 OLI/TIRS, and digital elevation model from Land development department as shown in Table 5-3.

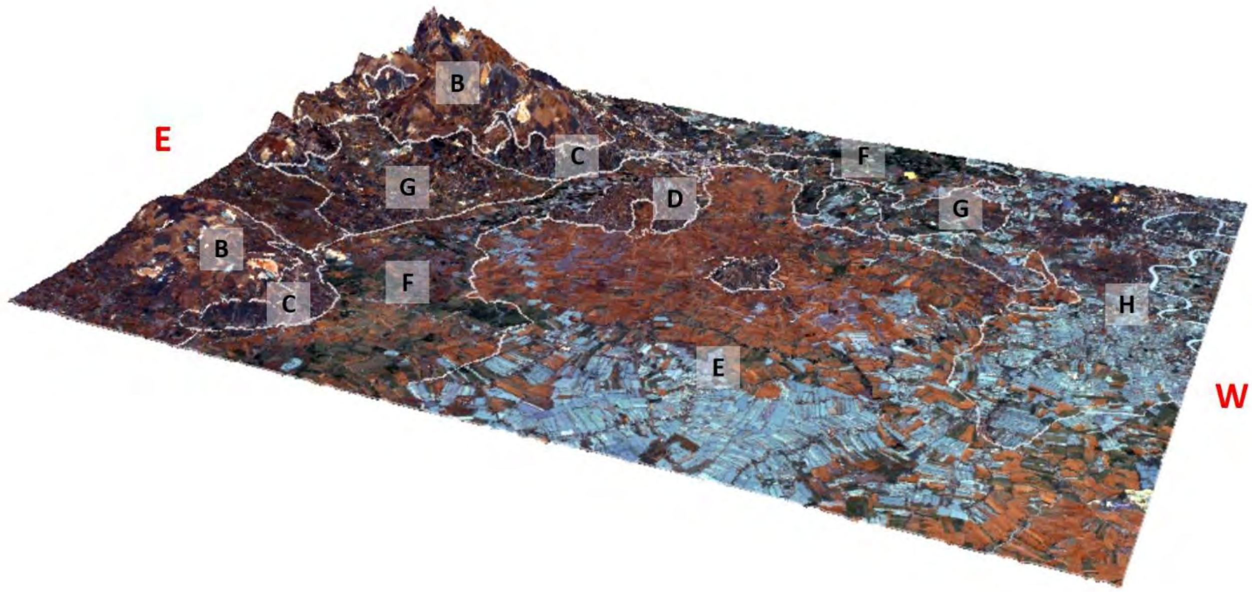

Figure 5-3 Three-dimensional model of Si Mahosot area shows the distribution of the surficial unit boundaries from this study and relationship to elevation (from MSL) which are related to their depositional and geomorphological characteristics

5.3 Limitation

The limitation of the study is urban disturbance which shows digitally characteristics and spectral range similar to unit C and the seasonal changes that may influence the digital images. These reasons effect to clearly define the surficial unit boundaries.

The similarity of physical properties of sediment and land covers that show the intimate spectral signature or grey level of pixels. It has an influence to accurate of supervised classification.

Table 5-3 The summarize of characteristics of the surficial deposits of Si Mahosot area

Unit[1]			Elevation[2]	Type[3]	Image characteristics (Landsat 8 OLI/TIRS)[4]			Physiographic position[5]	Typical surficial deposits grain size[6]
DMR (2007)	Takaya (1972)	Study			RGB: 777	RGB: 432	RGB: 127		
Qmc		E,H	Less than 2 meters	Coastal-tide dominated and recent fluvial dominated	Variable, White to light grey are soil surface and black is water body	Variable, light blue is water body, brown is soil surface and dark color is urban disturbance	Half Yellow and Blue shows the moist area	Floodplain along Bang Prakong river	(E) Greyish silt to clay size sediments and (H) blackish clay sediments
Qa	Loc 160, Loc 161, Loc 162	G,F	Less than 2 meters	Floodplain deposits	Light grey and black	variable, Brown in high land with grey and black in low land	Brown and Blue with mostly smooth texture and few rough texture cause of urban disturbance	(G) Channel deposit and (F) Flood plain deposit	(F) Dark brown silt to clay sediment with lateritic grain and (G) Brownish very fine sand size to clay sediment with few mottling
Qt	Loc 159	A,B,C,D	2-20 meters	Terrace deposits	Light grey and white with few black	Brown and dark brown with dot pattern	Blue with few yellow	High terrace and slope change area	Brownish to Reddish silt to clay, Some area has many grains and overlay laterite
Bedrock		A,B,C,D	more than 20 meters	Cover by terrace deposits					

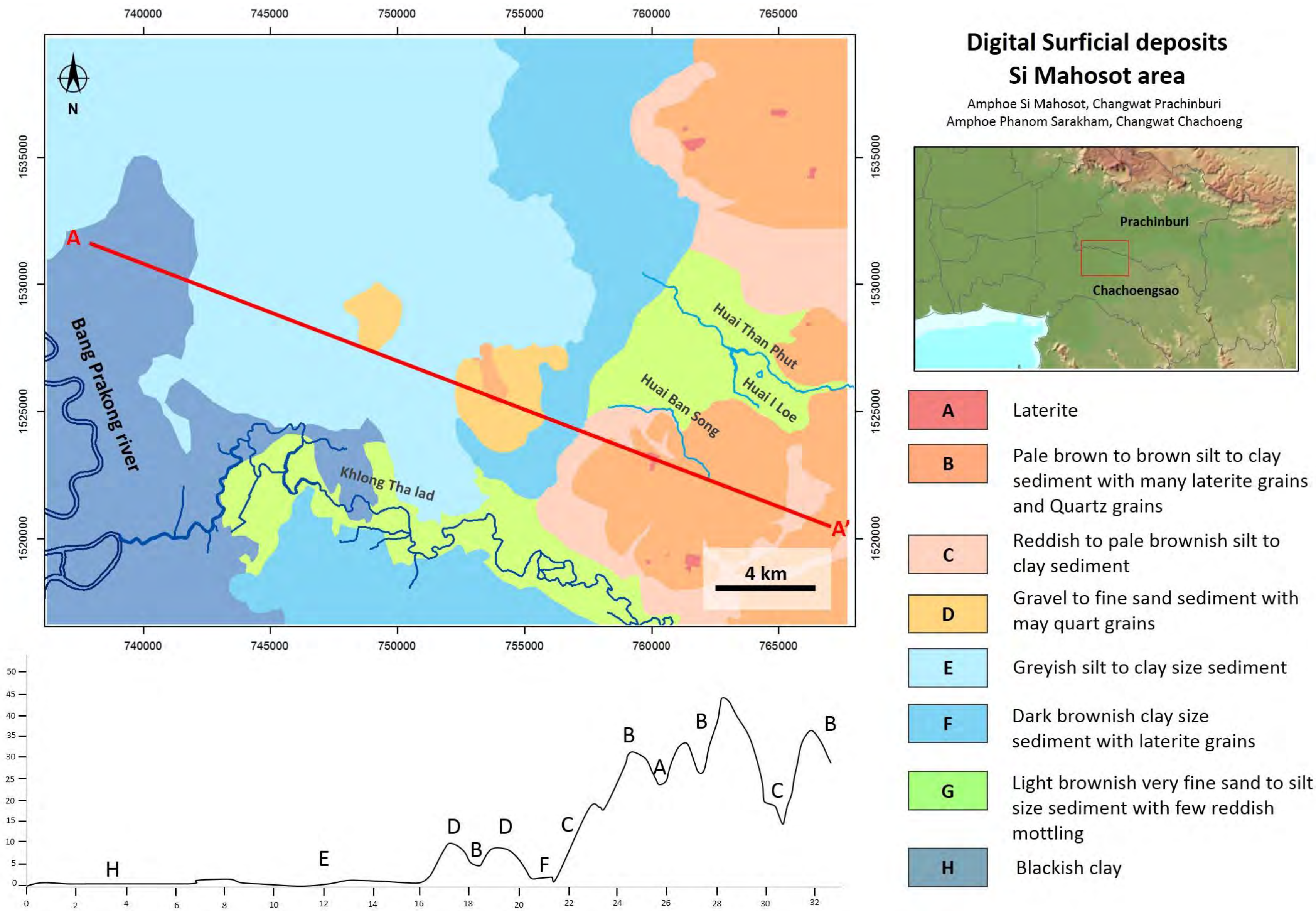

Figure 5-4 The digital surficial deposits map of Si Mahosot area with the cross section-line from A-A’

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Appendix

Table Field data from field observation, Simahosot area

St.	RS Unit	Map sheet no.	Map name	Coordinates				Physiography position	Drainge	Vegetation cover	elevation (m.) MSL	Lithological characteristics				sedimentary structure
				latitude	longitude	UTM_N	UTM_E					Type	Color	Typical Grain size	Composition	
1	G	5236II	Amphoe Phanom sarakham	13°43.06'	101°18.12'	1517784	749114	Low land	-	-	3	unconsolidated sediment	Grey	silt to clay	-	-
2	E	5236II		13°44.45'	101°20.49'	1520855	753788	Cutbank	Khlong Tha Lad	-	5	unconsolidated sediment	light brown	Very fine sand to clay	Few red mottling	Cross-gedding
3	C	5236I	Amphoe Si mahosot	13°47.227'	101°20.379'	1525414	752949	High land	-	-	11	unconsolidated sediment	light brown	Gravel to fine sand	Many quartz grains	-
4	F	5236I		13°48.161'	101°20.341'	1527136	752869	Low land	-	Paddy field	4	unconsolidated sediment	Grey to Dark brown	silt to clay	-	-
5	G	5236I		13°48.067'	101°22.946'	1527009	757566	Low land	Huai I Loe	Paddy field	3	unconsolidated sediment	Very dark brown	silt to clay	-	-
6	A	5236I		13°47.344'	101°24.522'	1525704	760421	High land	-	Cassava field	24	unconsolidated sediment	Pale brown	silt to clay	many quartz and lateritics grains	-
7	A	5236I		13°46.618'	101°26.559'	1524402	764107	High land	-	Cassava field	35	unconsolidated sediment	Pale brown	silt to clay	many quartz and lateritics grains	-
8	B	5236I		13°45.734'	101°27.307'	1522784	765473	highland	-	Cassava field	20	unconsolidated sediment	Pale brown to white	silt to clay	-	-
9	D	5236I		13°50.823'	101°25.378'	1532137	761900	low land	Huai Than Phut	-	10	unconsolidated sediment	Brown to red	very fine sand to clay	-	-
10	A	5236I		13°51.789'	101°25.634'	1533923	762343	high land	-	-	9	semiconsolidated sediment	Red	Laterite	-	-
11	A	5236I		13°52.790'	101°25.290'	1535763	761704	High land	-	-	16	semiconsolidated sediment	Red	laterite	intruded by quartz vein	
												sedimentary rock	White	weathered shale	intruded by quartz vein	Bedding 145°/40NE
12	C	5236I		13°52.951'	101°23.858'	1536035	759120	slope change	-	-	8	unconsolidated sediment	pale brown	silt to clay	many lateritic grains	-
13	F	5236I		13°52.331'	101°23.431'	1534883	758336	Low land	-	-	9	unconsolidated sediment	Dark brown	silt to clay	Quartz grains 5-10 percent	-
14	H	5236I		13°52.24'	101°23.03'	1534948	750495	Low land	irrigation canal	-	2	unconsolidated sediment	Grey	silt to clay	-	-

Table (Continued) Field data from field observation, Simahosot area

St.	RS Unit	Map sheet no.	Map name	Coordinates				Physiography position	Drainge	Vegetation cover	elevation (m.) MSL	Lithological characteristics				sedimentary structure
				latitude	longitude	UTM_N	UTM_E					Type	Color	Typical Grain size	Composition	
15	F	5236I	Amphoe Si mahosot	13°48.440	101°18.915'	1527626	750293	low land	-	-	1	unconsolidated sediment	Grey	very fine sand to silt	-	-
											13	unconsolidated sediment	pale brown	Gravel to fine sand	many quartz grains	-
16	C	5236I		13°48.949'	101°18.525°	1528558	749581	High land	-	-	6	semiconsolidated sediment	Red	Clay	-	-
									-	-	3	semiconsolidated sediment	Green	Clay	-	-
17	C	5236I		13°49.150'	101°18.443'	1528928	749430	High land	-	-	13	unconsolidated sediment	pale brown	Gravel to fine sand	many quartz grains	-
18	I	5236IV	Amphoe Bang nam priao	13°47.43'	101°12.23'	1526208	738535	Floodplain	Bang Prakong river	-	1	unconsolidated sediment	Black	Clay	-	-
19	I	5236III	Changwat Chachoengsao	13°44.40'	101°11.38'	1520556	737246	Floodplain	Bang Prakong river	-	1	unconsolidated sediment	Black	Clay	-	-

Soil description

Soil group	Soil characteristics
1	Fine-grained dark colored soils that occupy on low - lying terrain mostly in karst topography and basaltic terrain
2	Fine-grained soils that commonly occur on low-lying terrain of brackish water deposits, former tidal flat or flood plain
3	Fine-grained soils that occupy only on former tidal flat or alluvial plain
4	silty clay loam to silty clay soils which occur on flood plain or alluvial plain
5	clay or silty clay soils that occur on flood plain or alluvial plain
6	clay loam to clay or silty clay on flood plain or low-lying terrace
7	clay loam or silty clay loam to clay or silty clay, that commonly occur on flood plain and low-lying terrace or alluvial fans
8	fine-textured soils which have been amended either by fertilizer application with or without liming
9	typical acid surface soils that commonly contain high salt content at the soil surface
10	typical acid sulfate soils with extremely acidic condition occur along coastal plain on brackish water deposits
11	typical acid sulfate soils that are very strongly acidic occur mainly on the coastal plain of brackish water deposit
12	very muddy and poorly drained
13	very muddy and poorly drained which contain appreciable amount of pyrite
14	young acid sulfate soil along the coastal zone or coastal swamp
15	clay loan to silty clay loan soils that develops on alluvial plain or flood plain
16	silt loan grading to silty clay loan soils that developed mostly in the areas of alluvial plain or flood plain
17	sandy loam to sandy clay loam soils that occupy mostly on low - lying terrain of alluvial terrace
18	sandy loam to sandy clay loam soils that occupy mostly on low - lying terrain of alluvial terrace and high pH values
19	medium textured soils that occur mainly on low-lying terrain
20	coarse-textured soils that are salt affected and occupy on low-lying terrain of the north-east plateau and coastal plain
21	medium-textured soils that are commonly stratified with sand and silt layer that occur mostly on flood plain or alluvial plain
22	coarse-textured that occur on low-lying terrain

Soil description (Continued)

Soil group	Soil characteristics
23	coarse-textured loamy sand or sand and mostly probably found on coastal plain
24	coarse-textured that occupy on slightly undulating terrained coastal plain, alluvial terrace and wash surface
25	poorly drained soil and shallow that always occur mainly on low-lying of alluvial terraces and erosional surface
26	fine-textured that occurs mostly on erosional surface uplands of udic soil moisture regime in the southeast coast and peninsula south
27	fine-textured that occurs on basaltic terrain along the south-east coast
28	dark colored heavy clay that occupies in karst topography and basaltic terrain in ustic moisture regime
29	deep fine-textured that occupies erosional surfaces and alluvial terraces or fans in dry areas of the country
30	high weathered, fine-textured that occurs on mountainous areas in the northern part of Thailand
31	and fine-textured derived from fine-grained elastic rocks
32	medium-textured that developed from alluvial deposits along natural levee and flood plain in high precipitation areas
33	silt loam to silty clay loam always occur mainly on flood plain or alluvial fan in low rainfall areas
34	Sandy loam to sandly clay loam occupies on foot slopes, alluvial fan or terrace. Rainfall distribution of the areas is relatively high
35	sandy loam to sandy clay loam and occupies on uplands where precipitation is low
36	Sandy loam to sandy clay loam and occupies on uplands where precipitation is low but medium acid or neutral and reddish color. Dry-land upland and tree crops are commonly found in the areas
37	coarse-textured that developed from weathered rocks in dry areas
38	Coarse-textured that are commonly stratified with sand and silt. They are found on natural levee or flood plain in drier areas
39	coarse textured that developed from transported material derived from coarse-grained parent rocks
40	coarse-textured that develop from alluvial deposits or wash materials on the uplands of alluvial terraces, fans or erosional surface in the areas of low precipitation
41	coarse-textured that developed from alluvial deposits of wash materials on undulating terrain

Soil description (Continued)

Soil group	Soil characteristics
42	deep sandy occurs on beach ridge along the coastal line
43	Deep sandy occurs on beach ridge along the coastal line. The fertility is very low
44	deep sandythat occur on alluvial terraces, fans and wash surface
45	soils is well drained and shallow with lateritic or ironstone layer in less than 50 cm
46	soils is well drained and shallow with lateritic or ironstone layer in less than 50 cm and only be found low precipitation areas
47	Shallow to fine-grained bed rock. It occupies erosional surface, hills and mountains in low precipitation areas
48	Shallow to coarse-grained bed rock and commonly occur on erosional surface, hills and mountains
49	shallow with lateritic gravels and low fertility in low precipitation areas
50	Medium-textured and lateritic layers or bed rocks is found at the depth between 50 - 100 cm
51	shallow soils to bed rocks on erosional surface, hills and mountains with high precipitation
52	Shallow calcareous layer in low precipitation areas. Dark surface layer of salt that friable in moist condition
53	medium-textured, well drained and moderately deep that commonly developed from fine grained elastic rocks in high precipitation areas
54	fine-textured, well drained or moderately well drained in less precipitation areas that are developed from enrich carbonate and basic parent material
55	fine-textured that developed from elastic rocks in low precipitation areas
56	coarse grained elastic weathered-rock layer
57	organic soils in coastal swamps and underlying material is pyritic mud clay
58	organic soils in coastal swamp and underlying substratum is includes pyretic mud clay
59	Sandy, silty and gravelly layer are found alluvial-complex soils occupies alluvial plain and valley
60	Alluvial complex soils that are well-drained or moderately well drained with silt and sand layer. Soil qualities vary as source of parent materials
61	soils on the foot slopes or colluvium slopes
62	soils includes all steep lands

Scale 1:50,000

Data source: Land Development department

Available from http://www.ldd.go.th/web_eng56/Eng-detail/Soilgroup/index.html