Capt.Pongpun Juntakut[1]
Yaowaret Jantakat[2]
Prof.Juergen Ertel[3]

[1]The Department of Civil Engineering, Chulachomklao Royal Military Academy, E-mail : juntakut37@yahoo.com
[2]The Department of Information and Communication Technology, Faculty of Science and Art, Rajamangala University of Technology Isan, Nakhon-Ratchasima, 30000
[3]Faculty of Environmental Sciences and Process Engineering, Brandenburg University of Technology, Cottbus, Germany.

Classification of Agriculture Area

for Materials Flow Analysis

based on Digital Image Processing

Abstract

The principal goal of study attends to apply knowledge of Digital Image Processing (DIP) to analyse nitrogen flow that has got concept of Material Flow Analysis (MFA). Some reports mentioned interaction between nitrogen and agriculture area so this study has pointed to classify the agriculture area from the study area with DIP. This study has selected Samutprakran province as the pilot case for classification of agriculture area to study nitrogen flow. Significantly, definition of MFA concentrates on main two parameters: space and time, that relate to remotely sensed data. Therefore, these objectives of study focus on using DIP for identification of agriculture area to analyse nitrogen flow in Samutprakran province where is expected that will be affected by natural disaster and relevant to environmental condition e.g. tidal stages, that the expectation of the study would like to guideline for preparing in mitigation and prevention of the study area with using of satellite data in nitrogen flow analysis. Therefore, materials are used in this study included Landsat-TM 2000 and 2006 and operations were used in ERDAS programme such as preprocessing, unsupervised classification (ISODATA) and change detection.

As a result of this study, there are two main outputs. Firstly, agriculture area in period of 5 years (2000-2006) has been really changed in both conventional and change detection methods. Secondly, RS data between year 2000 and 2006 can serve concept of implement for Nitrogen Flow Analysis of agriculture area in Samutprakran province. Consequently, nitrogen using of agriculture area in 2000 and 2006 equal to 4.87 and 5.41 kg per m^2 respectively while nitrogen releasing of agriculture area over same periods are 1.03 and 1.13 kg per m^2 respectively. Additionally, this study has significantly found out relationship of nitrogen using and releasing in agriculture area of Samutprakran province that there is a same direction. For example, if a trend of agriculture area has increased, both using and releasing of nitrogen quantity will be higher.

Keywords : Landsat-TM, Digital Image Processing, Remote Sensing, Material Flow Analysis, Nitrogen, agriculture area

1. Introduction

At the present time, global warming is very important issue in the environmental problem for all countries that it is not only developed nations but it includes developing and poor nations too. Studies of them indicate that the average global surface temperature has increased by approximately 0.5-1.0°F (0.3-0.6°C) over the last century. This is the largest increase in surface temperature in the last 1,000 years and scientists are predicting an even greater increase over this century. Consequently, we have to find out causes and solutions for this issue. Global warming means an overall increase in world temperatures which may be caused by additional heat being trapped by greenhouse gases (1). Greenhouse gases occur naturally, such as water vapor, carbon dioxide, methane, nitrous oxide and ozone (2).

Furthermore, this study has intended to use and release nitrogen from agricultural processes. Therefore, this study has a point of view for nitrogen flow analysis on concept from equation (1) and figure 1 that is generally called in a term of ***"Material Flow Analysis (MFA)".*** MFA is systematic assessment of the flows and stocks of materials within a system defined in space and time (3).

$$\sum_{k_I} m_{input} = \sum_{k_O} m_{output} + m_{storage} \quad (1)$$

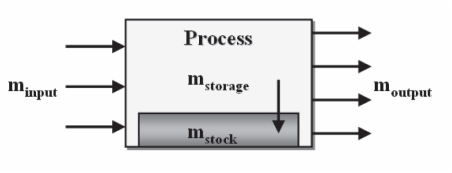


Figure 1 A simple model of MFA (3).

With definition of the above MFA, this study has discovered that it relates to acquisition of remotely sensed data in the terms of space and time. Therefore, this study has tried to classify agriculture area for MFA with digital image processing in any area that risk natural disaster such as Samutprakran province.

This study is divided into two main objectives: 1) to classify agriculture area through change detection with digital image processing, 2) to employ DIP in agriculture classification of study area from RS data for Nitrogen Flow Analysis.

2. Methodology

This study decided to select Samutprakran province (see Figure 2) as the pilot area for analysis of Nitrogen Flow based on DIP. There is reasonable for this study as follows: 1) This area is expected by some scientists, there is storm surge but the probability is about 10% (4), 2) This area are affected by tidal stages on Change Detection that this reason is one of environmental considerations (5) and 3) This area is

important source of economic zone in Thailand especially industries.

Figure 2 The study area from Landsat-TM, 2006.

For image preparing and analysis, this study used ERDAS program and some functions of ArcGIS in supporting them. To more understand clearly in this study, there is a comprehensive overall that can show in the below flowchart of methodology as follows:

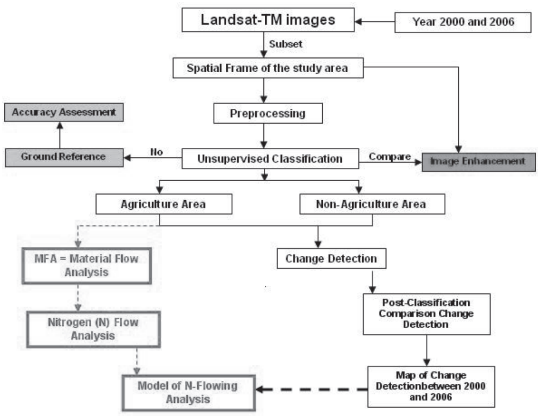


Figure 3 Flowchart of this methodology.

2.1 Landsat-TM images from Geodatabase of Suranaree University of Technology (SUT), Thailand.

The details of the satellite images for analysis as follows:

1) A base image in year 2000 includes three bands:

- Band 3 (Red = 0.6-0.7 μm)
- Band 4 (NIR = 0.7-1.3 μm)
- Band 5 (MIR = 1.3-3 μm)

2) A subsequent image in year 2006 (It is detected on October 22nd, 2006), there are 7 bands as this below table:

Table 1 Landsat-TM Characteristics (5).

Band	Spectral Resolution (μm)	Spatial Resolution (m)
1	0.450-0.515	30 X 30
2	0.525-0.605	30 X 30
3	0.630-0.690	30 X 30
4	0.750-0.900	30 X 30
5	1.55-1.75	30 X 30
6	10.40-12.50	60 X 60
7	2.08-2.35	30 X 30

In Landsat-TM 2006, we had decided to delete band 6 because of spectral and spatial resolution that no need in identification of agriculture area.

2.2 Determining a framework of the study area

In this step, the study area was provided by ERDAS and ArcGIS program to clip boundary Samutprakran province for Landsat-TM images of 2 periods. The output can be presented as Figure 2.

2.3 Preprocessing

Generally, there are three main preprocessing operations: (1) image quality assessment and statistical evaluation, (2) radiometric correction and (3) geometric correction (6). However, this step had operated especially the first operation only (see Figure 4) because other operations were already operated by GISTDA of Thailand that are product in level L1G (is already corrected in both radiometry and geometry), so the latter of two processes were not operated in this stage.

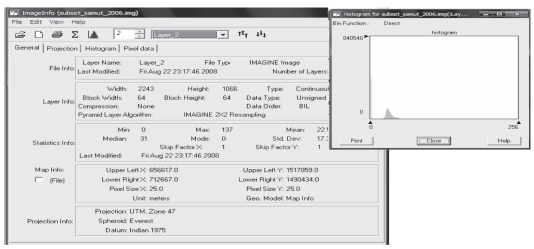


Figure 4 Operation of preprocessing (Image quality assessment and statistical evaluation).

Next, there were suitable three bands for agriculture classification had been chose that this study had designed to select Band 3, 4 and 5 between 2000 and 2006. The main aim of study needs to identify agriculture zone so band 4 was selected because it is designed to study vegetation. Moreover, band 4 is designed to analyses leaf structure and band 3 is usually studied in leaf pigment and both bands are commonly compared each other. If brightness value of band 4 is higher than band 3, it will point to greenness. For band 5, it is designed to detect water content (8). Reflectance of each mentioned band can show in Figure 5.

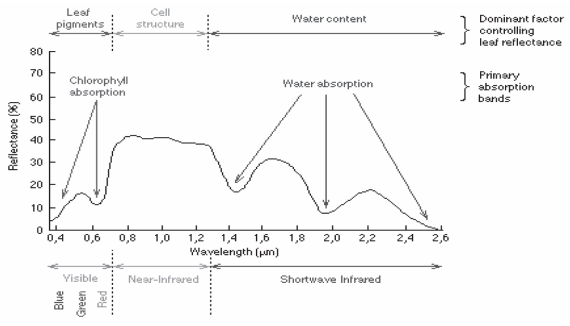


Figure 5 Graph of reflectance for perfect vegetation (8).

2.4 Unsupervised Classification

Classification of agriculture area in Samutprakran province was analysed by algorithm of ERDAS program that is called "ISODATA" is statistic method uses minimum spectral distance to assign a cluster for each candidate pixel (7). Moreover, the ISODATA method is iterative; it is not biased to the top of the data file, as are the one-pass clustering algorithm.

Actually, output of classification has to refer ground reference that is the step of accuracy assessment when finished in DIP in a pattern of error matrix (relationship between ground and RS data) However, this study had used comparison between image enhancement and classification in both Landsat-TM 2000 and 2006 to investigate instead of ground reference.

2.5 Change Detection

In this stage, the study used operation of post-classification that is one of change detection algorithm. This method has the processes are included:

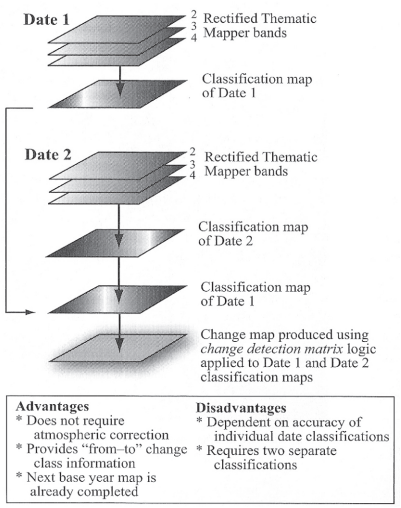


Figure 6 Processes of Post - Classification in Change Detection (5).

2.6 RS Application for MFA

According to concept of MFA, it defined input, process and output of material flow. Model of MFA have to determine a space and time before simulation of MFA model. This study was interested to simulate nitrogen flow in agriculture area of Samutprakran province so parameters can be described as follows:

1) The space

2) Time

3) Calculating input of Air Mass Flow means agriculture area intake the amount of nitrogen from air with assumption from 20% of agriculture area where is planted soybean in this study area (9) and can be calculated based on the following formula (11): Area that planted soybean x N fixation per area (150 kg N/ha or 24 kg N/rai).

4) Calculating output = Air Mass Flow of NO_X releasing from agriculture can be calculated based on the following formula (10):

$$Q_i^{\mathrm{N}}(t) = \sum_j Q_{i,j}^{\mathrm{N}}(t) \tag{2}$$

$$Q_{i,j}^{\mathrm{N}}(t) = \sum_f \sum_k Q_{i,j(k),f}^{\mathrm{N}}(t) \tag{3}$$

$$Q_{i,j(k),f}^{\mathrm{N}}(t) = (1 - p_{i,j(k),f}^{\mathrm{N}}(t)) K_{i,j(k),f}^{\mathrm{N}}(t) F_{i,j(k),f}^{\mathrm{N}}(t) \tag{4}$$

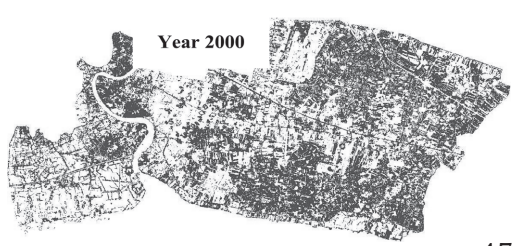
Where Q^N = NO_X emission calculated as NO_2; K^N = emission factor of NO_X weighed as NO_2; P^N = fraction of NO_X removed by pollution control; t = time; i = region; j = economic sector; $j(k)$ = emission source category; f = fuel type.

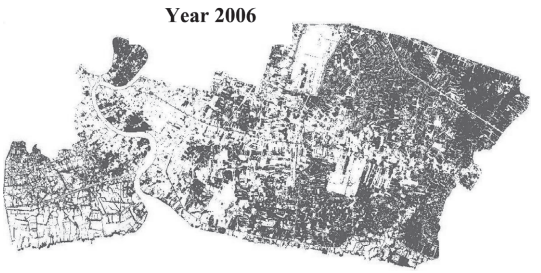
5) Presenting model of Nitrogen Flow analysis based on two factors: space and time.

3. Results

3.1 Result of Classification in year 2000 and 2006

Result of unsupervised classification in year 2000 and 2006 can show with the below images and table of classification.





Note: Blue and green define agriculture area in 2000 and 2006 respectively.

Figure 7 Results of unsupervised classification in year 2000 and 2006.

Table 2 Classification of year 2000 and 2006 (Unit: km^2).

Types/ Years	2000	%	2006	%	Change	%
A	406.72	41.97	451.87	46.63	45.15	4.66
NA	562.35	58.03	517.18	53.37	-45.17	-4.66
Total	969.07	100	969.05	100	-	-

Note: A = Agriculture
NA = Non Agriculture

From above data, this study obtained two main land-use types: agriculture and non agriculture area that can explain result of classification and changing between 2000 and 2006 are include:

- Agriculture area in year 2000 and 2006 are about 406.72 km^2 (41.97%) and 451.87 km^2 (46.63%), respectively. There is increasing of agriculture area amount +45.15 km^2 (4.66%) of total area.
- Non agriculture area in year 2000 and 2006 are about 562.35 km^2 (58.03%) and 517.18 km^2 (53.37%), respectively. There is increasing of agriculture area amount -4.66 km^2 (-4.66%) of total area.

3.2 Chang detection of Land-use between 2000 and 2006

Results of change detection can present as the below figure and matrix.

Note : Red defines agriculture area

Figure 8 Post-Classification between 2000 and 2006.

Table 3 Land-use matrix between 2000 and 2006 (Unit: km^2).

2000/2006	A	NA	Total
A	290.35	116.37	406.72
NA	161.53	400.82	562.35
Total	451.88	517.19	969.07

Note: A = Agriculture
NA = Non Agriclture

From above matrix, the result indicates that agriculture area in year 2000 has been changed to be agricultural and non-agricultural area in year 2006, by 290.35 and 116.37 km^2, respectively. Meanwhile, there is non-agriculture area in 2000 has been changed to be agriculture and non-agriculture area in yaer 2006, by 451.88 and 517.19 km^2, respectively

3.3 Nitrogen Flow Analysis (NFA)

According to concept of MFA, it concentrates in terms of input, process and output. Importantly, there are two parameters: space and time, which must put them in model before calculating quantity of nitrogen in both using and releasing at a certain time. As a result, the space is 969 km^2 of Samutprakran area and the certain time is determined in two periods: on October 25^{th}, 2000 and October 22^{nd}, 2006, can describe in the below table.

Table 4 Changing of Nitrogen Flow Analysis between 2000 and 2006.

Items/years	2000	2006	Remark
The space	969 km^2	969 km^2	Samutprakran area
Time	October 25^{th}, 2000	October 22^{nd}, 2006	-
Input	4.87 kg/m^2	5.41 kg/m^2	Section 2.6
Output	1.03 kg/m^2	1.13 kg/m^2	Eq. (4)

Remark:

Input = Area that planted soybean (9) x N fixation per area (150 kg N/ha or 24 kg N/rai) (11)

Output = (Denitrification, % of applied N (12) x Total N input to peri-urban agriculture) + (NO_2 from rice straw burning per rice yield (13) x rice straw burnt (14), (15))

Presenting model of Nitrogen Flow analysis in Samutprakran area (969 km^2) based on time October 25^{th}, 2000 and October 22^{nd}, 2006 are shown in Figure 9.

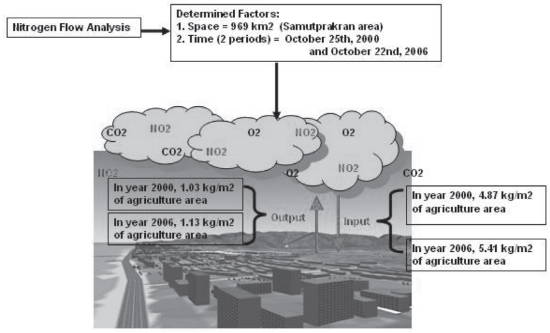


Figure 9 Nitrogen Flow Analysis in Samutprakran area based on time October 25^{th}, 2000 and October 22^{nd}, 2006.

4. Conclusions and Discussions

4.1 Agriculture area in period of 5 years (2000-2006) has been really changed in both conventional and change detection methods.

4.2 RS data between year 2000 and 2006 can serve concept of implement for Nitrogen Flow Analysis in agriculture area of Samutprakran province. Consequently, if agriculture area is changed, nitrogen flow will be varied by agriculture changing with same direction together (as shown Figure 10).

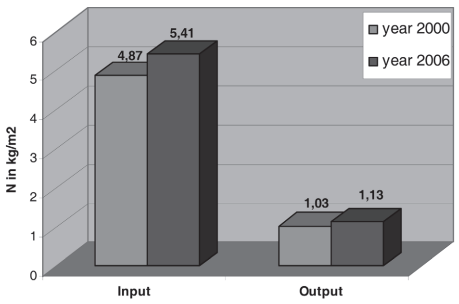


Figure 10 Nitrogen Flow Analysis in agriculture area of Samutprakran province between 2000 and 2006.

5. Recommendations

5.1 Although the result of classification already has checked to image enhancement, we would like to suggest that should improve it by ground reference because it is the best process of accuracy assessment.

5.2 If some researchers want develop this study, they have to be more study and understand technique of Digital Image Processing and Material Flow Analysis.

References

(1) National Weather Service, (2007). What is Global Warming. Website on-line http://www.srh.noaa.gov/jetstream//append/glossary_g.htm

(2) New York Times, (2008). What are Greenhouse Gases. http://environment.about.com/od/faqglobalwarming/f/greengases.htm

(3) Brunner, P. and Rechberger, H., (2004). Practical Handbook of Material Flow Analysis: What is MFA. LEWIS Publishers, A CRC Press Company, Boca Raton.

(4) Thairath newspaper, (2008). Environmental News. Website on-line www.thairath.co.th/news/environment

(5) Onsongwang, S., (2008). Lecture on Digital Image Processing on term 1st, 2008. School of Remote Sensing, Suranaree University of Technology. Nakhonrtchasima, Thailand.

(6) Onsongwang, S., (2007). Fundamental of Remote Sensing and Digital Image Processing. School of Remote Sensing, Institute of Science, Suranaree University of Technology.

(7) Leica Geosystem, (2002). ERDAS Field Guide: Unsupervised Classification. ERDAS LLC, United States of America.

(8) Tosananon, T., (2008). Lecture on Principle of Remote Sensing on term 1st, 2008. School of Remote Sensing, Suranaree University of Technology. Nakhonrtchasima, Thailand.

(9) Department of agricultural extension, (2005). Using Nitrogen in Agriculture area. Website on-line http://www.doac.go.th

(10) Kato, N. and Akimoto, H., (1992.) Anthropogenic emissions of SO_2 and NO_X in Asia: emission inventories. Atmospheric Environment 26, 2997 3017.

(11) Blasum, H., (1997). Wild legumes, vetch inoculation and rhizobial taxonomy in Xiaman farm, eastern edge of the Qinghai-Tibet plateau. MSc thesis. Grassland Lab, Biotechnology Department, Sichuan Union University, Chengdu 610064, PR CHINA.

(12) Olsen, S.R. and Kemper, W.D., (1968). Movements of nutrients to plant growth. Adv. Agron., 20, pp.91-149.

(13) Shang, S.Y., Chung, M.L., Chao, M.L., Yen, L.L., (2003). Estimation of methane and nitrous oxide emission from paddy fields and upland during 1990-2000 in Taiwan. Chemosphere 52 (2003) 1295-1305.

(14) Sinsupan, T., (2004). Master Thesis: Material Flux Analysis (MFA) for Planning of Domestic Wastes and Wastewater Management: Case study in Pak Kret Municipality, Nonthaburi, Thailand.

(15) Nguyen, T.T.T., (2006). Master Thesis: Material Flow Analysis as a Tool for Environmental Sanitation Planning in HaiPhong City, Vietnam. School of Environment, Resources and Development, AIT, Thailand.