Making a Land Use Map and Estimation of Agricultural Biomass Distribution in Northeast Thailand

Shigeo OGAWA, Chikara OGURA, Hiroshi YOSHISAKO and Takeo SHIMA
2-1-6 Kannondai, Tsukuba, Ibaraki, Japan
sogawa@affrc.go.jp

Abstract: In this study, we made a land use map in agricultural area in northeast Thailand using two Landsat/ETM+ images and ground survey data. At first, we made a crop calendar of main crops in order to make a land use map. Comparing classified land use map and test site map made from a panchromatic image of Quick Bird and ground survey. Paddy fields and fields of the land use map correspond to then of test site map. Further more, we estimate main crops (wet season rice, dry season rice, sugar cane, cassava) from time series NDVI images calculated from Landsat/ETM+ data sets. We will estimate agricultural biomass distribution using estimated crop cultivation map.

Keywords : land use map, Landsat/ETM+,

1. Introduction

Recently, global warming is one of the most important themes to solve in our earth. One method is to reduce the use of fossil fuel and shift to use of biomass energy, because the net emission of carbon dioxide will be zero as long as plants continue to be replenished for biomass energy purposes. We targeted agricultural biomass distribution and its quantity. Agricultural biomass is distributed in agricultural land and related to crop cultivation. If some biomass converting plant would be constructed, biomass quantity and its distribution are important factors to decide the plant size and its place.

We tried to estimate cultivating crops (wet season rice, dry season rice, sugar cane and cassava) using time series Landsat/ETM+ data sets.

2. Test site and used data sets

1) Test site

Test site is located Khon Kaen area, northeast Thailand. Its center position is East 102º 37', North 15º 56' (170km X 170km, Fig.1). Muang River and Chi River flow in the test site. Paddy uses lowlands, and crops such as sugarcane and cassava dominantly occupy uplands. Since Sandy Loam and Loamy Sand are the typical soil types, water-holding capacity is basically low. Soil erosion is observed after intensive rainfall and causes the collapse of paddy field levees in the lowlands. We made out small paddy field lots in Nong Saeng village located about 30km south of city of Khon Kaen. This small test site is about 7km X 5km.

Fig.1 Test site location

2) Used data sets

The time series satellite images are four Landsat/ETM+ and one Quick Bird/Panchromatic data sets. Quick Bird/Panchromatic data set is used for making out small paddy field lots. Landsat/ETM+ data set covers with about 170km X 170km.

Table 1 List of satellite data sets

Acquisition date	Satellite	Sensor	Resolution (m)	Used bands
2000/10/26	Landsat	ETM+	30	1,2,3,4,5,7
2001/11/30	Landsat	ETM+	30	1,2,3,4,5,7
2002/2/18	Landsat	ETM+	30	1,2,3,4,5,7
2002/4/7	Landsat	ETM+	30	1,2,3,4,5,7
2002/4/13	Quick Bird	Panchromatic	0.7	1

3. Methodology

The outline of the analysis is shown in Fig. 2 and details are as follows:

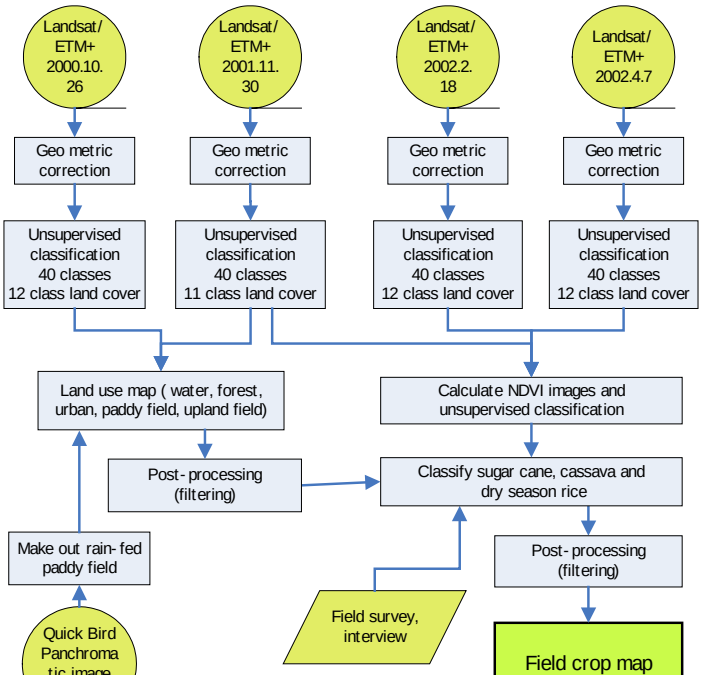


Fig. 2 Procedure of making a land use map and a field crop map

(1) Each image is geo-corrected referring to Landsat/TM by the Polynomial, re-sampling method is most neighborhoods. Geo-corrected pixel sizes are 30m. Ground control points are selected and RMSE is within 0.5 pixel size.

(2) Each Landsat/ETM+ image is classified into forty classes by unsupervised classification method (ISO DATA method). Forty classes are determined to eleven or twelve land cover classes.

(3) We made a land use map from two land cover maps classified from Landsat/ETM+ data sets (acquired on 26 October 2000 and 30 November 2001). Two land cover maps are combined by matrix table. Land use classes are river or pond, forest, paddy field, up-land field, and urban area.

(4) We made out small paddy field lots from Quick Bird/Panchromatic image. We compared paddy fields lots dataset and land use map made from two Landsat/ETM+ images if the land use map is correct or no.

(5) Created land use map contains errors, especially paddy fields are classified speckles in the up-land fields. Generally paddy fields are connected and gathered around the canal because they are distributed low land area and needed much water. We used 7X7 matrix and delete the small speckles of paddy fields twice. At first, if the number of paddy is less than eleven in the 7X7 matrix, center point of paddy is corrected to maximum land use class. Subsequently, if the number of paddy fields is less than 6, center point of paddy is corrected to maximum land use class. Decision rules of these methods were determined for the test fields.

(6) NDVI (Normalized Differences Vegetation Index) images are calculated from three Landsat/ETM+ images (acquired on 30 November 2001, 18 February 2002, and 7 April 2002), as the next equation.

$$NDVI = (Band4 - Band3)/(Band4+Band3) \text{ ------- } (1)$$

Where, Band4 is the band 4 of Landsat/ETM+ (near infrared band), Band3 is the band 3 (red band).

(7) Time series NDVI images of up-land fields are classified by ISO DATA method to 16 classes. Comparing to crop patterns, we decided upland field crops (sugarcane and cassava). Time series classified images (acquired on 18

February and 7 April) of paddy fields are classified to dry season paddy fields. Dry season paddy fields are flooded or growing rice in these terms. Finally, we combine field crops image and paddy fields image to one image.

4. Results and discussion

1) Land cover images and land use map

Each image was classified and re-classed referencing to ground survey data. Two Landsat images acquired on 26 October and 30 November are better to identify land use categories (pond or river, paddy fields, up-land fields, forest and up-land fields). Paddy fields and upland fields are not distinguished in dry season data because each field is dry and bare soil condition and both of reflection are similar. For example, Landsat image was classified and forty classes were distributed in two dimensions (Fig. 3). High vegetation classes are located upper side than soil line. Paddy rice has various distributions because growing stage and water environment is different. Clean water area is located lower left and turbid water area is lower right in Fig. 3.

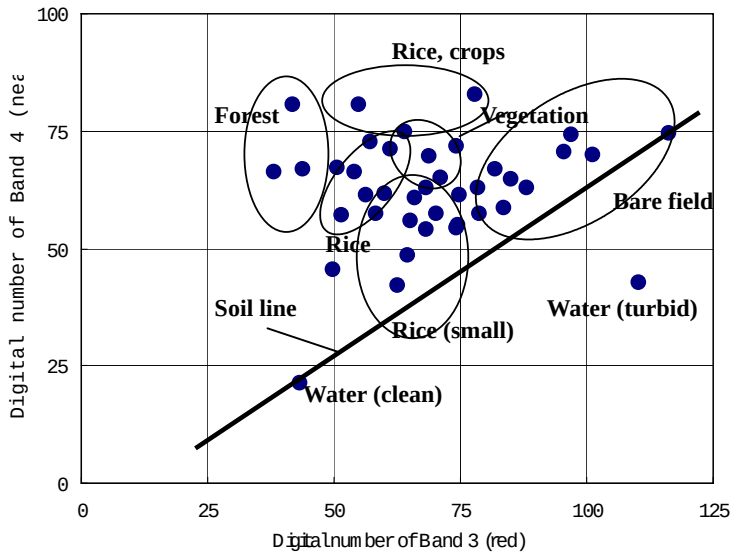


Fig.3 Distribution of forty classes in two dimension (2001.11.30.Landsat/ETM+)

Table 2 Land use category decision by matrix table

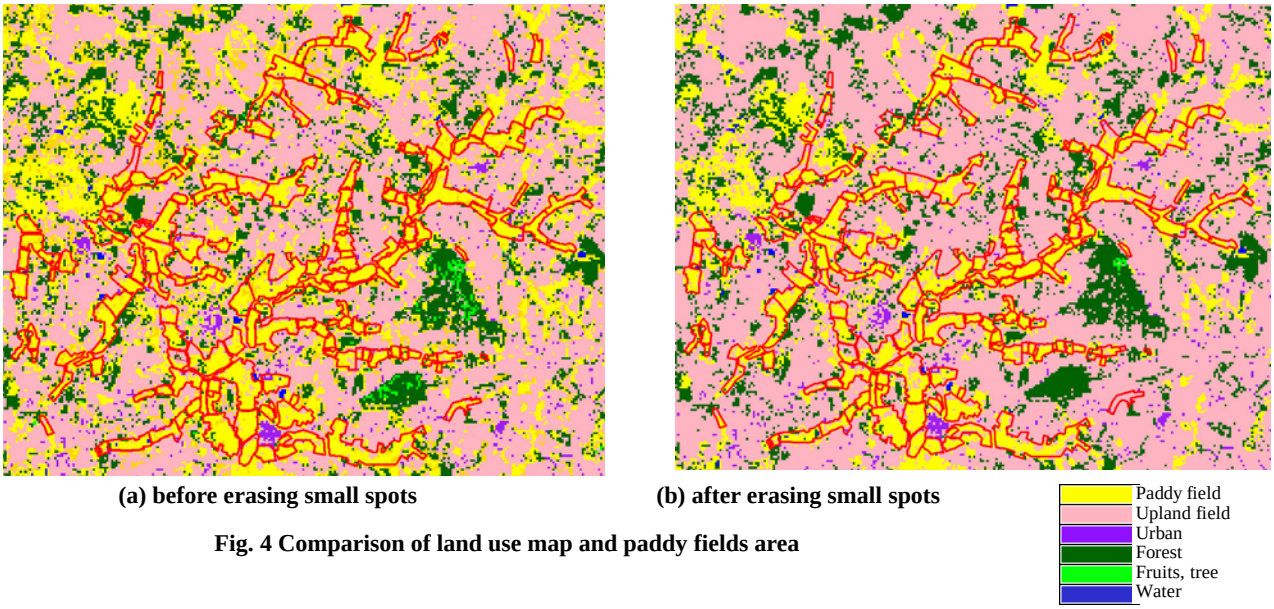
2000.10.26.ETM+ \ 2001.11.30.ETM+	0 out of Area	1 water	2 forest1	3 forest2, crops	4 paddy1(flooded, rice growing)	5 paddy2(rice growing)	6 paddy3(rice growing)	7 paddy4(no rice)	8 field1(crops)	9 field2(bare condition)	10 vegetation	11 urban, bare field
0 out of area 15313861(29.22%)	0 | (99.37)	1 | (0.01)	2 | (0.06)	3 | (0.04)	4 | (0.05)	5 | (0.03)	6 | (0.18)	7 | (0.15)	8 | (0.08)	9 | (0.01)	10 | (0.01)	11 | (0.01)
1 water 1242501(2.37%)	12 | (0.14)	13 water,paddy (36.86)	14 forest (2.28)	15 forest1 (3.05)	16 paddy,wetland (12.07)	17 paddy (18.38)	18 paddy (10.73)	19 paddy (9.58)	20 paddy (3.06)	21 paddy (0.18)	22 paddy (1.07)	23 paddy (2.58)
2 forest1 2419946(4.62%)	24 | (0.28)	25 paddy (0.35)	26 forest (20.55)	27 forest (16.11)	28 forest (15.62)	29 paddy (5.60)	30 paddy (19.37)	31 paddy (15.39)	32 paddy (3.84)	33 paddy (0.26)	34 paddy (0.65)	35 paddy (1.98)
3 forest2, crops 1017727(1.94%)	36 | (0.16)	37 water (0.18)	38 forest (32.56)	39 forest (40.71)	40 crops,forest (5.06)	41 paddy (2.14)	42 paddy (6.77)	43 paddy (5.95)	44 paddy (5.20)	45 field (0.10)	46 paddy (0.69)	47 paddy (0.47)
4 paddy1(flooded), cloud shadow 881617(1.68%)	48 | (0.10)	49 water (5.70)	50 forest (7.00)	51 forest (6.37)	52 wetland forest (18.08)	53 paddy (14.74)	54 paddy (20.50)	55 paddy (15.22)	56 field (7.76)	57 field (0.61)	58 forest (1.98)	59 paddy (1.96)
5 paddy2(small rice) 2206947(4.21%)	60 | (0.13)	61 water (4.12)	62 forest (5.41)	63 paddy (5.33)	64 paddy (18.56)	65 paddy (17.25)	66 paddy (20.23)	67 paddy (16.25)	68 paddy (7.06)	69 field (0.65)	70 paddy (1.70)	71 paddy (3.32)
6 paddy3(flooded, growing) 3789358(7.23%)	72 | (0.18)	73 water (0.88)	74 forest (5.22)	75 paddy (4.41)	76 paddy (18.89)	77 paddy (14.55)	78 paddy (24.44)	79 paddy (20.26)	80 field (5.59)	81 field (0.57)	82 field (1.38)	83 paddy (3.64)
7 paddy4(growing) 7603632(14.51%)	84 | (0.16)	85 water (0.11)	86 forest (7.12)	87 forest,paddy (7.22)	88 field crops (7.11)	89 paddy (5.44)	90 paddy (26.79)	91 paddy (32.68)	92 field, paddy (9.05)	93 field (0.20)	94 field crops (1.33)	95 paddy (2.79)
8 field1(crops), vegetation 9666205(18.44%)	96 | (0.16)	97 water (0.14)	98 forest (11.78)	99 forest (5.16)	100 forest (9.92)	101 paddy (4.72)	102 field (31.01)	103 paddy (22.80)	104 field (9.52)	105 field (1.48)	106 paddy (1.17)	107 paddy (2.15)
9 field2(bare field) 4259554(8.13%)	108 | (0.20)	109 water (0.34)	110 forest (8.15)	111 field (3.85)	112 field (11.82)	113 field (4.06)	114 field (29.06)	115 field (16.25)	116 field (16.59)	117 field (6.35)	118 field (1.46)	119 field (1.87)
10 vegetation 0(0%)	120 | (0.00)	121 | (0.00)	122 | (0.00)	123 | (0.00)	124 | (0.00)	125 | (0.00)	126 | (0.00)	127 | (0.00)	128 | (0.00)	129 | (0.00)	130 | (0.00)	131 | (0.00)
11 urban, bare field 917830(1.75%)	132 | (0.16)	133 water (0.69)	134 forest (2.84)	135 forest (2.81)	136 paddy (10.21)	137 paddy (4.55)	138 paddy (21.95)	139 urban (26.34)	140 field (14.80)	141 field (4.99)	142 field (1.86)	143 urban (8.80)
12 clouds 3094124(5.90%)	144 | (0.03)	145 water (1.83)	146 forest (10.89)	147 forest (9.59)	148 paddy (10.13)	149 paddy (6.74)	150 paddy (25.36)	151 paddy (18.88)	152 paddy (11.79)	153 field (1.30)	154 field (1.85)	155 urban (1.60)

Two Landsat images were re-classed and combine to one image by the rule of matrix table (table 2). This table was

determined from ground survey data and 1:50,000 scale maps.

2) Comparison land use map with small paddy fields area

In order to verify the land use map, small rain-fed paddy fields was made out from Quick Bird/Panchromatic image. Fig. 4(a) is overlaid land use map and paddy area made out from Quick Bird image. Each paddy fields area is correspond. In fig. 4(a), land use map has small paddy spots (classification errors) in the field or forest area. In order to erase these spots, we have done using 7X7 matrix. Small spots of paddy fields were erased (Fig. 4(b)).



(a) before erasing small spots **(b) after erasing small spots**

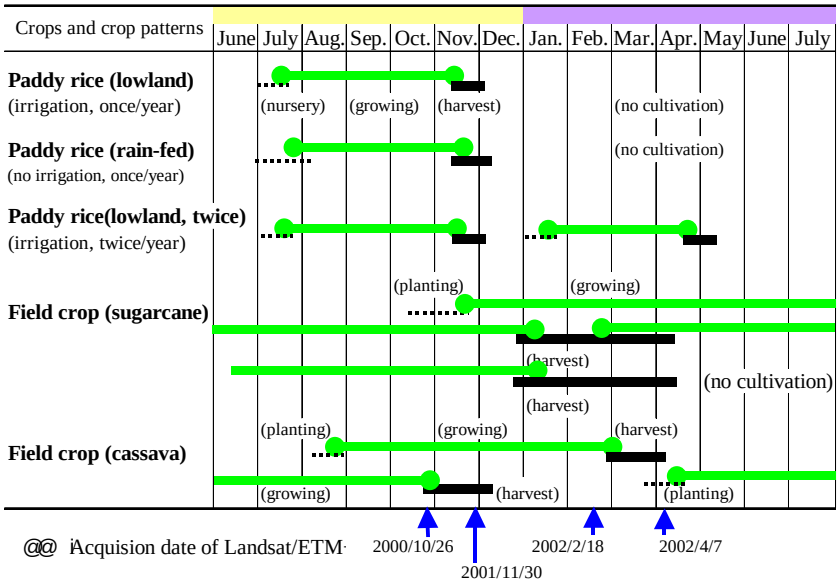
Fig. 4 Comparison of land use map and paddy fields area

3) Crop type estimation

We made a crop calendar based on field survey and interviews to farmer in test site (Table 3). Main crops are paddy rice (once/year or twice/year), sugarcane and cassava.

Dry season paddy fields are identified as water covered areas in 2002/2/18 image and 2002/4/7. Estimation of flooded paddy field is established in Japan (Ogawa et al., 1990).

Table 3 Crop calendar in Khon Kaen area



Based on this cropping patterns and time series NDVI images (2001/11/30, 2002/2/18, and 2002/4/7), upland field crops are classified to sugarcane and cassava. Classified forty classes data from NDVI images are shown in Fig. 5. Each category is estimated as follows.

Cassava1 is growing on 11/30 and harvested before 2/18. Cassava2 is planted in April. Sugarcane1 is panted in November. NDVI is low this term and increases in April. Bare field is low NDVI in three images. Grass is middle NDVI in three images. Forest and fruits garden tree are high NDVI in 11/30 and 2/28, it is middle NDVI in 4/8 because of dry season.

Using these methods, we can estimate main crop distribution in Khon Kaen area, Northeast Thailand. But, we don't check the statistical data. We will compare estimate value with statistical data. Further more, we estimate the amount of agricultural biomass.

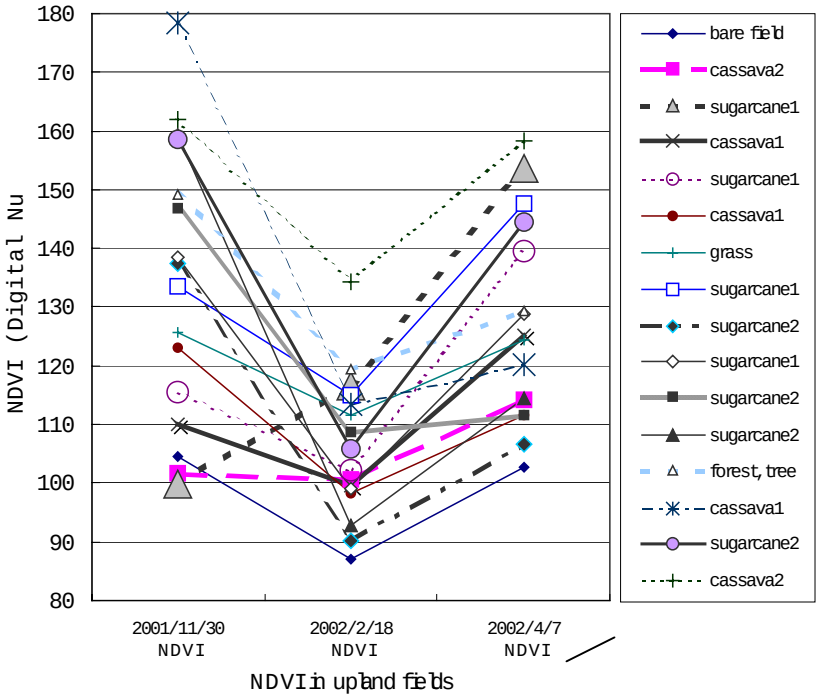


Fig. 4 Classification of time series NDVI in upland fields

Conclusion

Using time series Landsat/ETM+ images, we can make land use map and estimate main crop map (rainy season paddy fields, dry season paddy fields, sugarcane and cassava).

Crop calendar is important to make land use map and main crop map. We try to erase small spot paddy fields by 7x7 matrix. This method has good advantage to correct the land use map.

Acknowledgements

The authors would like to acknowledge the financial support from the Research Project for Effective Utilization of Biomass in Asia and the Revolutionary Research Project "Coexistence of People, Nature and the Earth (RR2002) funded by Ministry of Education, culture, Sports, Science and Technology. Their thanks also go to the Khon Kaen office of Japan International Research Center for Agricultural Sciences for giving agricultural information.

REFERENCE

Ogawa S., Miyama K. and Fukumoto M., 1990. "Study on land use classification using remote sensing images." *Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering at Hokkaido region, No.216*, pp. 1-7.