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Standardized Agricultural Land Use Classification Scheme at Various Spatial Resolution of Satellite Images

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Abstract

This study is to present a standardized agricultural land use classification scheme at various spatial resolution (from 1 m to 30 m) of satellite images including Landsat TM, KOMPSAT-1 EOC, ASTER VNIR and IKONOS panchromatic (PAN) and multi-spectral (MS) images. The satellite images were interpreted especially for identifying agricultural land use, crop types, agricultural facilities and structures of 18 items. It was found that there is a threshold spatial resolution between 4 m and 6.6 m to identify the full items. Thus it is suggested that IKONOS fusion image (MS enhanced by PAN) is required to produce land use map for agricultural purpose.

Keywords : spatial resolution, agricultural land use, classification scheme, IKONOS

I. Introduction

In South Korea, even though satellite images have been recognized to have a potentiality for practical use in the field of agriculture, there have been many constraints in obtaining, designing, and analyzing images because of their high prices, low usability of temporal series, and low spatial resolution for our agricultural applications. Fortunately, as the government perceived the importance of earth remote sensing satellite of our own, KOMPSAT-1 (KOrea Multi-Purpose SATellite-1) launched at 1999 is in operation with 6.6 m spatial resolution of EOC (Electro-Optic Camera) and KOMPSAT-2 of 1 m resolution panchromatic (PAN) band and 4 m resolution multi-spectral (MS) band is scheduled to be launched in 2005. Thus, it is expected that a lot of agriculture-related information can be obtained from the images of KOMPSAT-2, and furthermore the images will play a role to update rural GIS data and to activate data use for

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agriculture and precision farming.

Generally, remote sensing can provide information both on biophysical variables such as surface temperature, soil moisture, evapotranspiration and hybrid variables such as land cover mapping and vegetation stress. Many satellite remote sensing images at various spatial resolutions from Landsat MSS (79 m x 79 m), TM (30 m x 30 m) to SPOT HRV XS (20 m x 20 m), Landsat 7 ETM^{+} (15 m x 15 m) have been applied mainly to forest canopy, crown, trunk and leaf to get vegetation variables.

Among the variables, land use mapping is an important application field of remote sensing technology. But in South Korea, Landsat and SPOT did not offer high spatial resolution enough to clearly discriminate boundaries between forest and farm land in our cultivation scale of agriculture. Recently, the appearance of higher spatial resolution such as KOMPSAT-1 EOC (6.6 m x 6.6 m), and IKONOS PAN (1 m x 1 m) and MS (4 m x 4 m) have aroused the possibility to build a detail land use map in rural areas. For urban land use studies, the USGS land use/land cover classification system has been used extensively for more than two decades. On the other hand, few studies were performed for rural/agricultural land use mapping. Thus, the purpose of this study is to present a standardized scheme for providing agriculture-related information at various spatial resolution of satellite images and to check the feasibility of land use mapping for agricultural purpose using IKONOS image.

Ⅱ. Study Area, Remote Sensor Data and Preprocessing

The study area as shown in Fig. 1 is Gosam-myeon in Anseong-si with agro-environmental

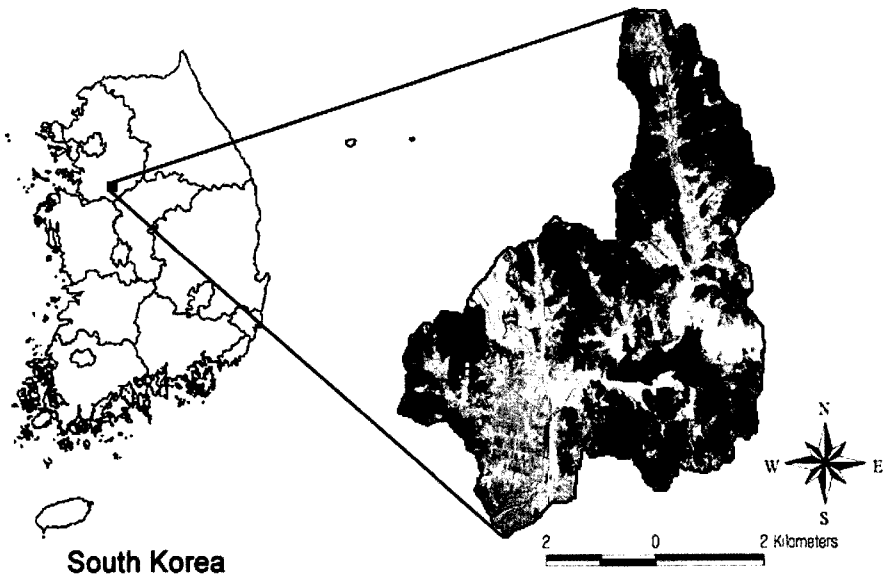


Fig. 1 Study area.

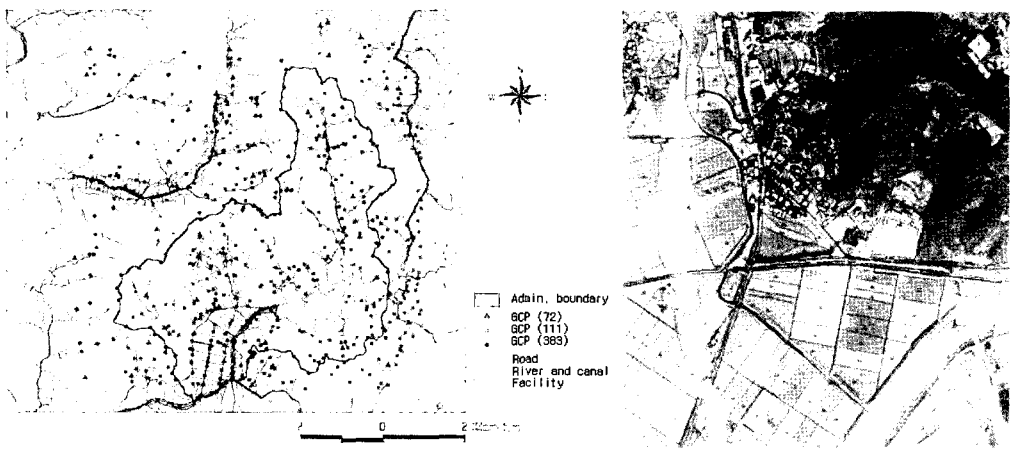
diversity. It lies between the coordinates of latitude N 37° 03′ 31″ to N 37° 07′ 53″ and longitude E 127° 13′ 56″ to E 127° 18′ 16″. For total area of 27.8 km^2, 52.0 % is forest, 16.8 % paddy field, upland crop farming land/orchard 6.6 %, and grassland 2.7 %.

Table 1 shows the selected images applicable on evaluating for agriculture land use items from various spatial resolutions. IKONOS Standard Geo Level images, KOMPSAT EOC, ASTER VNIR were ortho-rectified by using GCPs and 5 m DEM from 1:5,000 NGIS digital map and in-situ GPS data acquired from Trimble Geo-Explorer III. Generic Pushbroom Model of ERDAS (1999) IMAGINE OrthoBASE 8.5 was used for ortho- and geo-rectification. Fig. 2 shows the IKONOS image before- and after ortho-rectified 2 IKONOS images. Other images were corrected by image to image method based on ortho-rectified IKONOS image.

Table 1 The selected satellite images and their rectified results

Images	Resolution (m)	Date of Acquisition	GCPs	RMSE (m) x/y/z
IKONOS Pan	1	May 25, 2001	513	3.40/3.38/1.07
IKONOS MS	4		499	1.54/1.69/0.25
IKONOS Pan	1	Dec. 25, 2001	509	3.12/3.10/0.75
IKONOS MS	4		497	0.73/1.05/0.12
KOMPSAT EOC	6.6	June 26, 2002	32	2.50/2.73/1.05
ASTER VNIR	15	Mar. 11, 2002	22	5.47/1.35/1.49
Landsat 7 ETM^+ Pan*	15	June 03, 2001	18	3.29/4.01/-
Landsat 7 ETM^+ MS*	30		18	3.23/4.01/-

* Landsat: applied standard geo-rectification



(a) GCPs before (b) after

Fig. 2 Ortho-rectification.

Ⅲ. Comparison of Field Investigation and Satellite Imageries at Various Spatial Resolution

Field investigation was carried out to check the crop type, canopy status, agricultural facilities and structures at the photographing time of IKONOS image. The investigated results were compared with IKONOS PAN image, and evaluated items that can be identifiable based on IKONOS PAN image. The items determined from IKONOS 1 m image were compared with other satellite images from 4 m to 30 m spatial resolutions, which were graded into 4 levels; identifiable, identifiable but need field investigation to determine the type, presumable, not presumable.

Table 2 shows the result of 6 Level II (Level III – 18 items) agriculture-related items (paddy, upland crop, grass, reservoir, canal, and road) identifiable at various spatial resolutions. For each spatial resolution from 1 m to 30 m, the numbers of identifiable items were 15, 10, 4, 2 and 2, respectively. The total numbers of

Table 2 Detection ability of agriculture-related items at various spatial resolution (1 m~30 m) of satellite images

Classification items		1 m	4 m	6.6 m	15 m	30 m
paddy	consolidated	●	●	●	●■	●■
	not consolidated	●	●	■◎	◎	◎
	green house	●	●	■	◎	◎
upland	mulching	●	■◎	×	×	×
	upland crop	●■◎	■◎	◎	×	×
	orchard	■◎	■◎	◎	◎	×
grass	pasture	●■	●■	■◎	◎	×
	grassland	■◎	■◎	◎	×	×
	golf course	●	●	●	■	■
reservoir	small scale	●	●	●	■◎	◎
	middle scale	●	●	●	●	●
	weir	●■◎	●■◎	■◎	◎	×
canal	main canal	●	●	◎	◎	×
	primary canal	●	●■	◎	◎	×
	secondary canal	■◎	◎	×	×	×
	vegetation canal	●■	■◎	×	×	×
road	national road	●	■	◎	×	×
	farm road	●	■◎	◎	×	×

Note) (●) identifiable, (■) identifiable, but need field investigation to determine the type, (◎) presumable, (×) not presumable
1 m: IKONOS Fusion Color, 4 m: IKONOS MS, 6.6 m: KOMPSAT Fusion Color, 15 m: ASTER VNIR, 30 m: Landsat 7 ETM+

identifiable items with/without plus identifiable items with field investigation were 18 and 17 (except secondary canal), 8, 4, 3 (consolidated paddy, golf course, middle sized reservoir), respectively. Spatial resolution of 6.6 m could identify 8 Level III items and they were limited to grass, paddy and reservoir. If the presumable item is included, 2 upland, 2 canal and 2 rural road items can be classified.

From the discussion, we can infer that there is a threshold resolution between 4 m and 6.6 m to identify the 18 items presented in this study, and we can suggest that spatial resolution higher than 4 m is enough to identify our agriculture-related items with naked eye.

Ⅳ. Suggestion of Agriculture-related Land Use Mapping with High Spatial Resolution Image

For agricultural land use mapping with 1 m IKONOS image, MOCT (Ministry of Construction and Transportation) and MOE (Ministry of Environment) (2001) land use classification systems were reviewed; the former based on NGIS, but the other based on satellite remote sensing data and USGS (United States Geological Survey) (1999). The classification items were selected considering the result of identifiable items of Table 2. The standardized scheme for agriculture-related information with 1 m spatial resolution satellite image is suggested as in Table 3.

Table 3 Land use classification scheme for agriculture with 1 m spatial resolution image

Class	Code	Description
paddy	111	consolidated paddy
	112	green house in the consolidated paddy
	121	not consolidated paddy
	122	green house in not consolidated paddy
upland	211	upland crop
	212	mulching in upland
	221	feed crop
grass	311	grassland
	312	pasture
	321	golf course
water	411	stream
	412	wetland
	421	reservoir
paved and bare	511	residential area and livestock farm
	512	bare land
	513	cutted ground for development
	521	national road
	522	rural road
forest	611	conifer forest
	621	broad-leaved forest
	631	mixed foret

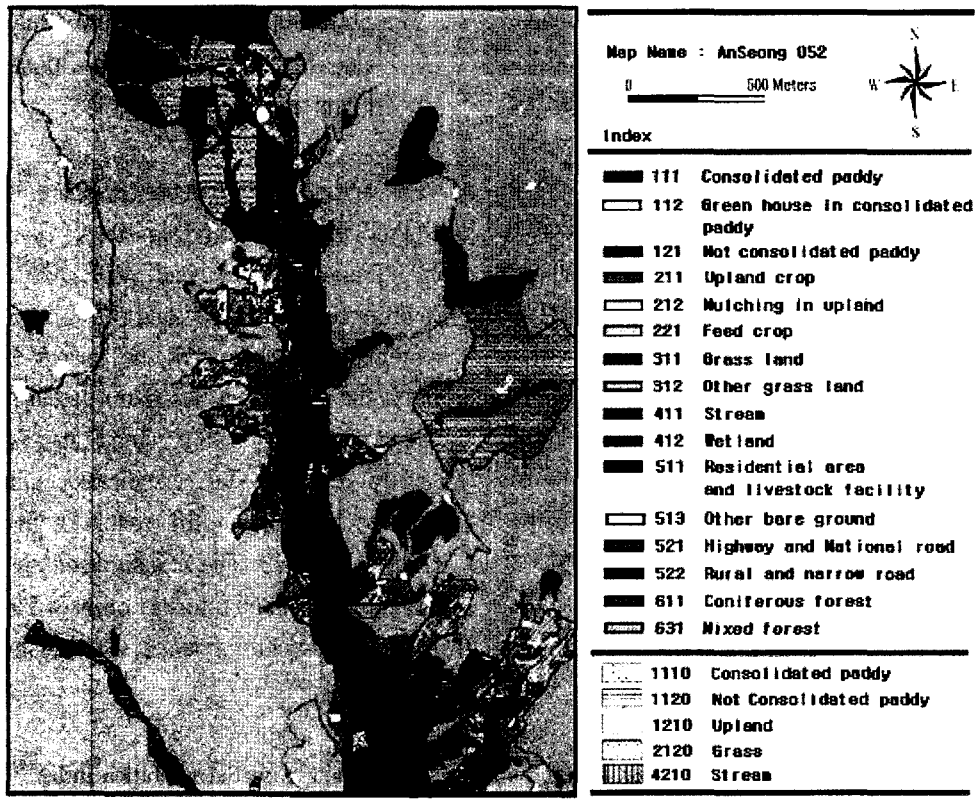


Fig. 3 Agricultural land use map produced by 1 m color fusion image overlaying with 1:25,000 land use map produced by MOCT.

Following the suggested land use classification system, agricultural land use map was made out using IKONOS 1 m fusion color image (4 m MS + 1 m PAN). Forest was classified with unsupervised classification and others were partitioned with digitizing. The map (filled) was compared with 1 : 25,000 scale land use map (hatched) produced by MOCT in 1998 (Fig. 3). Land use map of MOCT was produced by aerial photograph and field investigation with 38 survey items. Among the items, agriculture-related items are paddy, upland, orchard and rangeland. Because the two maps have 5 years time difference, some differences in rangeland and cultivation boundaries are found between two maps.

V. Conclusion

A standardized scheme for providing agriculture-related information at various spatial resolution of satellite images from 1 m to 30 m was presented. From the detection ability check of agriculture-related items, we could infer that there is a threshold resolution between 4 m and 6.6 m to identify the 18 items presented in this study, and we can suggest that spatial resolution higher than 4 m is enough to identify our agriculture-related items with naked eye. With the land use classification system suggested in this study, agricultural land use mapping was tried to produce using IKONOS 1 m fusion color

image. The map was compared and matched well with MOCT land use map produced in 1998.

Acknowledgements

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