SEMI-AUTOMATIC EXTRACTION OF AGRICULTURAL LAND USE AND VEGETATION INFORMATION USING HIGH RESOLUTION SATELLITE IMAGES

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ABSTRACT: This study refers to develop a semi-automatic extraction of agricultural land use and vegetation information using high resolution satellite images. Data of IKONOS satellite image (May 25 of 2001) and QuickBird satellite image (May 1 of 2006) which resembles with the spatial resolution and spectral characteristics of KOMPSAT-3. The precise agricultural land use classification was tried using ISODATA unsupervised classification technique and the result was compared with on-screen digitizing land use accompanying with field investigation. For the extraction of vegetation information, three crops of paddy, corn and red pepper were selected and the spectral characteristics were collected during each growing period using ground spectroradiometer. The vegetation indices viz. RVI, NDVI, ARVI, and SAVI for the crops were evaluated. The evaluation process is under development using the ERDAS IMAGINE Spatial Modeler Tool.

KEY WORDS: High resolution satellite images, Precise agricultural land use, Vegetation information, IKONOS, QuickBird

1. INTRODUCTION

For a practical use of high resolution image on an agricultural field, the development of new technology for the extraction and analysis of precise agricultural information is necessary. In South Korea, even though satellite images have been recognized to have a potential for practical use in the field of agriculture, there have been many constrains in obtaining, designing, and analyzing images because of high prices, little images of temporal series, and coarse spatial resolutions for agricultural applications. Fortunately, the government perceived the importance of earth remote sensing satellite of our own, KOMPSAT (KOrea Multi-Purpose SATellite)-1 launched at 1999 was in operation and KOMPSAT-2 was launched at 2007 (Kim et al, 2004). KOMPSAT-3 that will have spatial resolutions of 0.8 m panchromatic and 2.8 m multi-spectral images is scheduled to launch in 2011. KOMPSAT-3 image can produce USGS Level IV land use data (Kim et al., 2007). The accumulation of crop information from KOMPSAT-3 image and field investigations can help the identification of agricultural species, cultivation area, and crop condition during the growth stage.

In this study, a semi-automatic extraction of agricultural land use and vegetation information using high resolution satellite images is described.

2. MATERIAL AND METHODS

2.1 Remote Sensor Data and Preprocessing

Table 1 shows the collected images for agricultural land use and vegetation information from high resolution images which resembles with the spatial resolution and spectral characteristics of KOMPSAT-3.

Table 1. The selected satellite images

Images	Date of Acquisition	Resolution. (m)	Latitude / Longitude Coordinates
IKONOS-2	**May 25, 2001**	**Pan. 1 m** **MS. 4 m**	N 37° 03′ 31″ to N 37° 07′ 53″ E 127° 13′ 56″ to E 127° 18′ 16″
IKONOS-2	December 25, 2001	Pan. 1 m MS. 4 m	
IKONOS-2	October 23, 2003	Pan. 1 m MS. 4 m	
QuickBird-2	November 17, 2004	Pan. 0.63 m MS. 2.4 m	N 36° 48' 51" to N 36° 52' 48" E 127° 40' 23" to E 127° 46' 59"
QuickBird-2	**May 01, 2006**	**Pan. 0.63 m** **MS. 2.4 m**	N 37° 11' 05" to N 37° 12' 00" E 127° 15' 46" to E 127° 16' 36"

The IKONOS panchromatic and multi-spectral image of 25 May 2001 and the QuickBird image of 1 May 2001 were analysed for this study (Figure 1). IKONOS-2 satellite data can get the image of the spatial resolution of 1 m of panchromatic and 4 m of multispectrum. The study area is Gosam-myeon in Anseong-si with agro-environmental 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″. IKONOS Standard Geo Level image was ortho-rectified by using GCPs (Ground Control Points) and 5 m DEM (Digital Elevation Model) from 1:5,000 NGIS digital map and in-situ GPS data acquired from Trimble GeoExplorer III. Generic Pushbroom Model of ERDAS IMAGINE OrthoBASE 8.5 was used for ortho- and geo-rectification.

QuickBird-2 satellite data can get the image of the spatial resolution of 0.61 m at perpendicular, 0.73 m at angle of 30 degrees in the case of panchromatic, and 2.44 m at perpendicular, 2.9 m at angle of 30 degrees in the case of multispectrum. The study area is a small agricultural watershed (1.16 km^2) located in the upstream of Gyeongan-cheon watershed of Gyeonggi-Do Province in South Korea. It lies between the coordinates of latitude N 36° 48' 51" to N 36° 52' 48" and longitude E 127° 40' 23" to E 127° 46' 59". The QuickBird image was ortho-rectified and geometrically corrected using 2 m DEM from NGIS 1:5,000 digital map and 30 GCPs acquired from SOKKIA GPS (Global Positioning System) equipment.

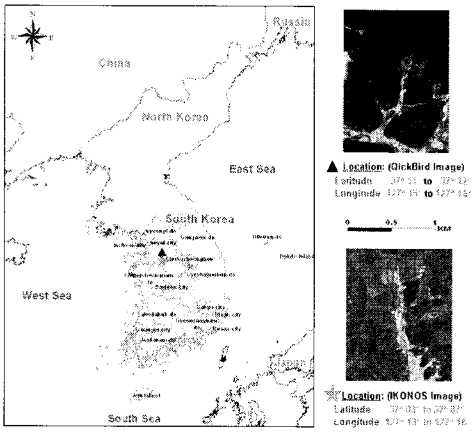


Figure 1. The location of study area.

2.2 Land Use Data Preparation Using On-Screen Digitizing Method

The IKONOS land use was made out using IKONOS 1 m fusion color image (4 m MS + 1 m PAN, 25 May of 2001). Forest was classified with unsupervised classification and others were partitioned by on screen digitizing (Hong et al., 2004). The land use was classified with more than 16 categories.

The QuickBird panchromatic and multi-spectral images of 1 May 2006 were used. The land use was produced by on-screen digitizing method with GPS field investigation data. The land use was classified with more than 23 categories. Figure 2 shows the land use produced by the IKONOS image (a) and QuickBird image (b).

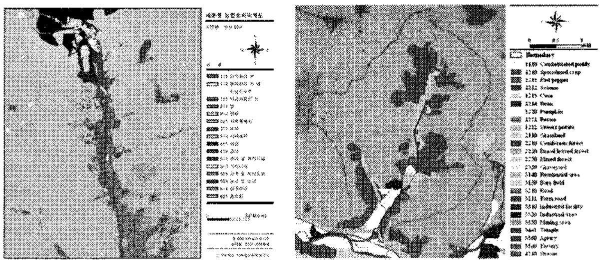

(a) (b)

Figure 2. The classified land use from IKONOS image (a) and QuickBird satellite image (b).

2.3 Field Investigation Data

Field investigation (Figure 3) was carried out to check the crop types, canopy status at the same time of IKONOS and QuickBird image acquisition. For the extraction of vegetation information, three crops of paddy, corn and red pepper were selected and the spectral characteristics were collected during each growing period using ground spectroradiometer.

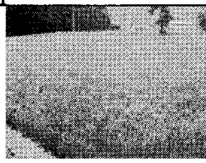
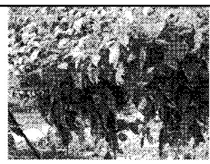
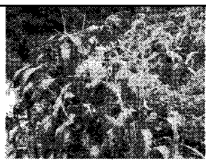
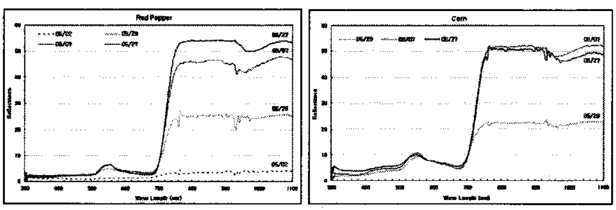
Field Crop	 Paddy	 Red Pepper
Growing Period	April ~ October	April ~ September
Field Crop	 Corn	 Coniferous Forest
Growing Period	May ~ August	Four Seasons

Figure 3. Field investigation of the study area.

The vegetation information and LAI were measured using the LI-1800, Spectroradiometer and the LAI-2000, Plant Canopy Analyzer, respectively during the growing season at Chungbuk Agricultural Research & Extension Service's farm (Sin, 2003). Reflectance measurements in paddy and crops field were conducted with a narrow band spectrometer (2nm) in the 300 nm to 1,100 nm wavelength ranges. Figure 4 shows the spectral reflectance of the crops, red pepper and corn.



(a) Red pepper (b) Corn

Figure 4. Spectral reflectance of the crops.

2.4 Spectral Vegetation Indices

Vegetation information was represented by four vegetation indices. These indices are given in Table 2. SR, NDVI, and SAVI were computed using red and near-infrared bands. ARVI uses three bands (blue, red and near-infrared bands).

Table 2. The selected vegetation indices

Vegetation Index	Formulae
SR (Simple Ratio) RVI (Ratio Vegetation Index)	$SR=\frac{\rho_{nir}}{\rho_{red}}=RVI$
NDVI (Normalised Difference Vegetation Index)	$NDVI=\frac{\rho_{nir}-\rho_{red}}{\rho_{nir}+\rho_{red}}$
SAVI (Soil Adjusted Vegetation Index)	$SAVI=\left(\frac{\rho_{nir}-\rho_{red}}{\rho_{nir}+\rho_{red}+L}\right)(1+L)$
ARVI (Atmospherically Resistant Vegetation Index)	$ARVI=\left(\frac{\rho_{nir}-\rho_{rb}}{\rho_{nir}+\rho_{rb}}\right)$ $\rho_{rb}=\rho_{red}-\gamma(\rho_{blue}-\rho_{red})$

ρ_{red}, ρ_{nir} and ρ_{blue} are red, near-infrared, and blue reflectance, respectively. For the SAVI, L is a canopy background adjustment factor set at 0.5.

3. RESULTS AND DISCUSSION

3.1 Analysis of the Precise Agricultural Land Use using Unsupervised Classification Land Use Data

Growth condition for paddy and upland crops was evaluated using filtering and unsupervised classification method. As the result of filtering, Mode filter method was more accurate than Gaussian filter method on visual analysis. ISODATA clustering method among unsupervised classification methods was employed and the analysis was conducted by adjusting number of clusters; 10, 15, 20, 30 and 50. As the result, in case of high resolution images, each crop boundary was appeared to a certain degree when the number of cluster is over 20. Especially paddy and corn were distinguished better than other crops on 1 May 2006 (QuickBird image). The paddy, corn, and grapes were distinguished better than other crops on 25 May 2001 (IKONOS image).

3.2 Selection of the Optimum Bands by Crops

In order to analyze the growth condition for paddy and crops, optimal bands were tried to determine. Crops average pixel values of each band were adopted as data inventory of crop information. Figure 5 shows the band 1, band 2, band 3 and band 4 average pixel values for the selected crops of 25 May 2001 and May 01 of 2006. The values of 25 May ranged widely compared to the values of 1 May. This means that May 1 image is better to discriminate each crop than May 25.

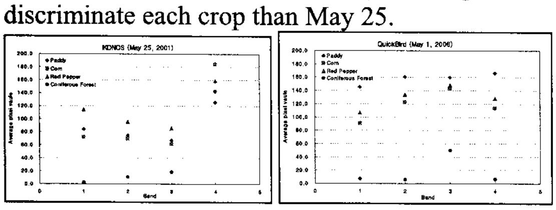


Figure 5. The average pixel values of selected crops for four bands of May 25, 2001 (IKONOS image) and May 1, 2006 (QuickBird image).

3.3 Comparison of Field Investigation and High Resolution Satellite Images Using Vegetation Indices

The Simple Ratio Vegetation Index (SR or RVI) is calculated using the following Equation 1.

$$SR=\frac{\rho_{nir}}{\rho_{red}}=RVI \quad (1)$$

If both the Red and NIR bands have the same or similar reflectances, then the SR is 1 or close to 1. SR values for bare soils generally are near 1 as the amount of green vegetation increases in a pixel, the SR increases. Note that the SR is not bounded its values can increase far beyond 1. Generally, very high SR values are on the order of 30.

Rouse et al. (1974) developed what is now called the generic Normalized Difference Vegetation Index (NDVI),

$$NDVI=\frac{\rho_{nir}-\rho_{red}}{\rho_{nir}+\rho_{red}}=\frac{IR_{850}-RED_{650}}{IR_{850}+RED_{650}} \quad (2)$$

where ρ_{nir} and ρ_{red} refer to the reflectance values derived from spectral radiances measured by the near-infrared band and the red band, respectively. The NDVI has a range limited to a value from -1 to 1. Data from vegetated areas will yield positive values for the NDVI due to high near-infrared and low red reflectances. As the amount of green vegetation increases in a pixel, NDVI increases in value up to nearly 1.

The Soil-Adjusted Vegetation Index (SAVI) is a superior vegetation index for low cover environments (Huete, 1998),

$$SAVI=\left(\frac{\rho_{nir}-\rho_{red}}{\rho_{nir}+\rho_{red}+L}\right)(1+L) \quad (3)$$

where L is a constant that is empirically determined to minimize the vegetation index sensitivity to soil background reflectance variation. If L is 0, SAVI is the same as NDVI. For intermediate vegetation cover ranges, L is typically around 0.5. The factor $(1+L)$ insures the range of SAVI is the same as NDVI, namely -1, +1 (Robert, 1997).

SAVI was made less sensitive to atmospheric effects by normalizing the radiance in the blue, red, and near-infrared bands. This became the Atmospherically Resistant Vegetation Index (ARVI),

$$ARVI=\left(\frac{\rho_{nir}-\rho_{rb}}{\rho_{nir}+\rho_{rb}}\right) \quad (4)$$

$$\rho_{rb}=\rho_{red}-\gamma(\rho_{blue}-\rho_{red})$$

The technique requires prior correction for molecular scattering and ozone absorption of the blue, red, and near-infrared remote sensing data, hence the term ρ. ARVI uses the difference in the radiance between the blue band and the red band to correct the radiance in the red band and thus reduce atmospheric effects. Unless the aerosol model is known a priori, gamma (γ) is normally equal to 1.0 to minimize atmospheric effects. Kaufman and Tanre (1992) provided guidelines where different gammas might be used over continental, maritime, desert, or heavily vegetated areas (John, 2000).

By applying the above prepared four vegetation indices (RVI, NDVI, ARVI, SAVI), the growth status of crops were estimated. Table 3 and Table 4 summarize the results for vegetation indices using IKONOS (May 25, 2001) and QuickBird image (May 01, 2006) respectively.

Table 3. The four vegetation indices by crops using IKONOS

Item	May 25, 2001 (IKONOS image)			
	RVI	NDVI	SAVI	ARVI
Paddy	0.61	0.26	0.39	0.20
Red Pepper	0.71	0.17	0.25	0.05
Corn	0.39	0.44	0.66	0.38
Coniferous Forest	0.01	0.97	1.46	1.23

Table 4. The four vegetation indices by crops using QuickBird

Item	May 01, 2006 (QuickBird image)			
	RVI	NDVI	SAVI	ARVI
Paddy	1.04	-0.02	-0.02	-0.06
Red Pepper	0.90	0.06	0.09	-0.04
Corn	0.86	0.08	0.11	-0.04
Coniferous Forest	0.12	0.81	1.20	0.84

The field investigated results were compared with IKONOS (May 25 2001) NDVI data and QuickBrid (May 01, 2006) NDVI data (Table 5).

Table 5. Comparison of Field Investigation and High Resolution Satellite Images Using NDVI

Item	NDVI	
	Red Pepper [%]	Corn [%]
May 25, 2001 (IKONOS image)	0.17 [24.3]*	0.44 [69.8]
May 01, 2006 (QuickBird image)	0.06 [15.0]	0.08 [40.0]
Field Investigation : 25 May	0.70	0.63
Field Investigation : 1 May	0.40	0.20

3.4 Semi-Automatic Extraction of Agricultural Land Use and Vegetation Information using Resolution Satellite Images

The evaluation process is under development using the ERDAS IMAGINE Spatial Modeler Tool. Figure 6 shows the flow chart of semi-automatic extraction of agricultural land use and vegetation information.

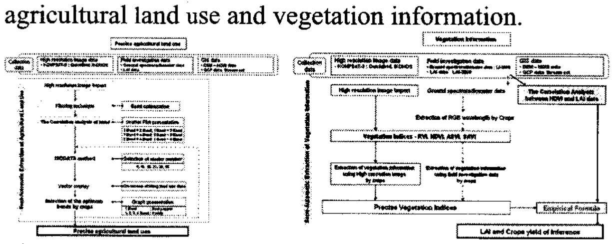


Figure 6. Process for semi-automatic extraction of agricultural land use and vegetation information

4. CONCLUSIONS

This study described the methodology and procedures for a semi-automatic extraction of agricultural land use and vegetation information using IKONOS satellite image and QiuckBird satellite image. If the crop information from both images and field investigations are accumulated for couple of years, reasonable crop mapping, crop condition and crop yield estimation would be possible.

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