Availability of QuickBird for land resource management in northern Laos

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Abstracts: QuickBird launched in 2001 provides the highest spatial resolution of commercial satellites, and it has been widely applied for urban planning, natural/man-made disaster monitoring etc. In addition to Panchromatic data with 60 cm/pixel resolution, Multi-spectral data with 4 bands including near-infrared is also equipped, thereby, QuickBird is useful for vegetation and agriculture analysis. In this study, to consider the availability of QuickBird for land resource management in slash-and-burn agriculture in northern Laos, the differences of data characteristics by land use were compared. The study site was Houayyen village in Luang Prabang Province. It located in the hilly mountainous area and predominant land use was upland rice cultivation implemented by short term rotation with cropping and fallow.

QuickBird images acquired in July 2003, September 2004, and March 2005 were ortho-rectified using DEM derived from ASTER/VNIR. To complete the pixel matching among dataset securely, Image-to-Image registration and re-sampling was performed by Triangulation and Nearest Neighbor method, and GPS information were assigned into geo-referential points.

Using Multi-spectral and Panchromatic imagery, data characteristics of the typical land use, i.e. upland rice field, fallows with different fallow length, river, etc. were investigated by the trend of Digital Number, NDVI and Texture indices. The results showed that the differences in fallow length were found in NDVI, and the separability by land use was found in some Texture indices, e.g. Mean, Variance, Homogeneity, Contrast and Dissimilarity. In addition, the superiority of resolution in QuickBird was useful to make field boundary map. It will be applied for the construction of field database including field survey data.

Keywords: Laos, QuickBird, Slash-and-burn agriculture, Texture analysis

1. Introduction

In northern Laos, short term rotation farming consisting with fallow for 3-5 years and cropping for 1-2 years have been widely practiced. The system is same with slash-and-burn agriculture, but fallow period is shorter than conventional shifting cultivation and it causes deterioration of crop production by soil degradation. In the previous studies, it found that time-sequential analysis using Landsat/ETM+ was available to identify crop-fallow rotation cycle, and regeneration process in fallow was estimated by Normalized Difference Vegetation Index (NDVI) (Yamamoto et.al, 2004). However, the conditions are not necessarily uniform
within the plot because fields are distributed on steep slope and used by non-tillage and non-fertilizing. In this study, therefore, the availability of high resolution satellite imagery, i.e. QuickBird, was considered to detect the precise information in the mountainous agriculture.

2. Data and Methods

The study site was Houayyen Village, Xiengun District, Luang prabang Province in Laos. The population was 349 persons by 57 households and the dominant geo-linguistic ethnic group was mountain and plateau group namely Lao-Theung. The land of agriculture in the community was approximately 45 ha and the most of them was upland. Yields of upland rice, that is pre-dominant crops, were 1.2 ton/ha, 0.5-0.6 ton/ha, and 0.3-0.5 ton/ha in the fields of good, moderate and deteriorated condition, respectively. Other crops such as sesame, Job’s tears, cotton, maize, etc. are occasionally cultivated as alternative.

Panchromatic and Multi-spectral QuickBird imagery acquired in July 2003, September 2004, and March 2005 were used for the analysis (Fig. 1). They were formatted by the same projection and resampling methods, however, the geographic coordinate at the same position were slightly different by the data and were not completely overlaid by their own original coordinate. To improve the georeferential matching among imagery, they were Ortho-rectified referring DEM derived from ASTER/VNIR in the same site, and geometrically corrected by Image-to-Image registration matching to the image of March 2005. The software used for the analysis was ENVI 4.0, and it has three kinds of warp methods, i.e. RST (Rotation, Scaling and Translation), Polynomial, and Triangulation. By the comparison of trials, the effect of correction by Triangulation was superior to other two methods and it was applied for warping. However, since the study site located in mountainous region and topography was complicate, the warping for the whole of site together could not be performed sufficiently. Accordingly, image was divided into some portions to warp respectively, and re-composed into a whole image. In addition, they were adjusted by assignment of GPS data to the Ground Control Points (GCPs) identified in the image to refer field survey data easily. By the operations, dataset for the analysis was created (Fig.2).

Based on field observation, typical land use areas were selected to investigate data characteristics in QuickBird imagery.
Using Multi-spectral imagery, Digital Number (DN) and NDVI in the fallow were compared by fallows length. And using Panchromatic imagery, eight indices of texture characteristics, namely Mean, Variance, Homogeneity, Contrast, Dissimilarity, Entropy, Second Moment, and Correlation, in upland rice field, fallows with different fallow length and river were calculated by filtering method based on co-occurrence matrix. In the operation, different window size of 3x3, 7x7, 9x9, 15x15, 17x17, 21x21, 25x25, and 33x33 were applied to consider the relation between texture on each land use category and spatial size. Panchromatic imagery was also applied to make land use map by interpretation.

3. Results and Discussion

DN and NDVI in the four plots with different fallow period were investigated using calibrated Multi-spectral imagery acquired in September 2004 (Fig. 3, Fig.4). Fallow A was immediately after harvest, and Fallow B, C, and D had been fallowed for 1, 2 and 3 years. The obvious differences were not found in Band 1, 2 and 3, but Band 4 showed the differences slightly by the fallow length. When it transferred into NDVI, it was gradually increased according to the order of Fallow A, B and C, i.e. after harvest, 1 year and 2 years of fallow, however, Fallow D that was 3 years fallow were nearly same with Fallow C.

When the fallow length was different, not only biomass but also texture was also different due to mixture of plant species and growing stage (Fig. 5). The differences in texture was remarkable in the dry season imagery, therefore, textures in the above four fallow plots and slash-and-burn practiced plot and upland rice field were analyzed using Panchromatic imagery acquired in March 2005 (Fig. 6). Within 8 texture indices, 5 indices eliminating Entropy, Second Moment, and Correlation showed separability by land use. Especially, Fallow C, Fallow D, and Upland rice were clearly isolated in any indices. In addition, the change by window size for filtering was also investigated. By the result, it was constantly increasing in Variance and Entropy, and
decreasing in Second Moment as window size was increasing, but other texture indices did not show the influences by window size.

The superiority of resolution in QuickBird is strongly useful to identify plot boundaries. Upland in the study site is rotated cropping and falling by several years cycle, but the plot boundary is often changed because cropping area was enclosed by slash. In the Panchromatic imagery acquired in dry season, fallow, forest, upland, paddy, etc. could be identified, and land use map was produced by interpretation and digitizing (Fig. 7). The map will be available to detect the changes of plot boundaries and to make map database consisting of information obtained by field surveys.

Through the above results, we considered that the differences of fallow length could be described to a certain extent by NDVI and Texture analysis, and site-based database could be constructed. The authors implement field survey on soil physics and fertility in the various conditions of land use and topography. In those area, since human-made input as fertilizer is not expected, the soil characteristics might determine the plant re-generation in fallow and crop production. The differences of vegetation accompanied with soil condition will be analyzed to evaluate the spatial potentiality for crop production.

**Acknowledgement**

This research has been implemented in the JIRCAS International collaborative research project entitled “Increasing Economic Options in Rainfed Agriculture in Indochina through Efficient Use of Water Resources”. The authors would like to extend their thanks to Mr. Xaysana Xayarath in CIAT, Mr. Kongkeo Phachomphon in Soil Survey and Land Classification Center for their assistances.

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Fig. 6. Texture Indices of different land use, calculated by Panchromatic image acquired in March 2005.

Fig. 7. Land use map produced by interpretation of QuickBird Panchromatic band acquired on 31/03/2005.