THE INFLUENCE OF SOIL CONDITION TO SATELLTE IMAGE IN MONGOLIAN GRASSLAND

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ABSTRUCT:
Nowadays, observation of soil condition using remote sensing on bare soil area is still in progress. Topographic feature, soil grading, soil moisture, base rock and vegetation might be influenced satellite image. Ground truth on the soil condition which is topography, soil moisture and soil grading had been carried out in Mandal-GOBI, Mongolia on every August from 1999 to 2002. The test area had clear atmosphere and uniform land cover. Moreover base rock might be assumed homogeneity. In this study, Landsat 7 -ETM was used because of including the short wave infrared band which can detect soil condition. Ground truth showed the soil moisture disregarded in the Landsat 7 -ETM image because of very dry condition. Therefore topographic influence could be easily removed from Landsat 7 image by shading of digital elevation model. The removing topographic influence image called corrected image in this study. In observing area, vegetation condition was very thin which average of NDVI using the corrected image was –0.031. And Band 7 of the corrected image was efficient to detect soil grading in such thin vegetative area. Value of corrected image had tendency to drop with big soil grading.

1. INTRODUCTION

Soil observation using remote sensing usually uses a microwave sensor and optical sensor with a narrow short wave infrared range. However these observation methods have not clearly explained the reflectance spectrum corresponding to soil conditions: topography, soil moisture, soil grading, base rock and soon. Moreover land cover and atmospheric conditions make difficult analysis. Therefore it is important to study the relationship between satellite image and soil conditions. Ground truth to get verification data set about soil conditions in uniform landcover areas is requested.

2. OBJECTIVES

This study aim is evaluating the influence of the soil condition in satellite image. It is important to compare satellite image with ground truth data. As ground truth on soil condition, topography, soil moisture and soil grading, were observed. Test area was selected in Mandal-GOBI Mongolia because of clear atmosphere and uniform landcover. The test area size was 2 km x 2 km. Base rock might be assumed homogeneity in test area. After that, the results of ground truth are concluded. Soil conditions will be compared with Landsat 7 -ETM image. When soil moisture can disregard, topographic influence is removed from satellite image using hill shading image [(1)] (A YOSHINO, 2001). The image of removing topographic influence will be generally influenced vegetation and soil condition. If Influence of vegetation can disregard from the image using NDVI, the image will be compared with soil grading.

3. OBSERVATION ITEMS

3.1 Topography

Topography was surveyed by the kinematics method using 1cycle GPS. Numbers of observed points were 5,487. DEM was generated as TIN (Triangulated Irregular Network) using all surveying points [(5)] (T KADOTA, 2000). Figure 1 shows derived contour map from the DEM.

3.2 Soil Moisture

Soil moisture contents were measured by FDR soil moisture meter. Figure 1 shows measurement points of soil moisture content on the contour map. The soil moisture meter can measure a volume of soil moisture ratio per $1m^3$. Measurement points ranged from 3 cm to 5 cm in depth.

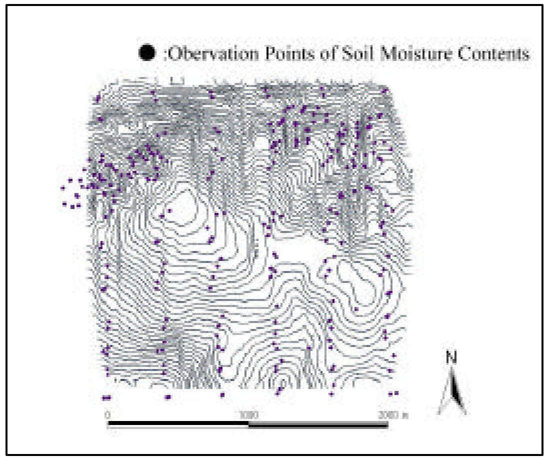

Figure 1. Observation Points of Soil Moisture Content on Contour Map

3.3 Soil Grading

Soil grading was measured by CCD camera. The camera mounted on observation car (Figure 2). The CCD camera can take surface images from 2 m height. Figure 3 shows measurement points of soil grading on contour map. Number of measurement was 355. Soil grading was classified into five categories by visual interpretation from the images. Figure 4, 5 shows example image of class1 to 5.

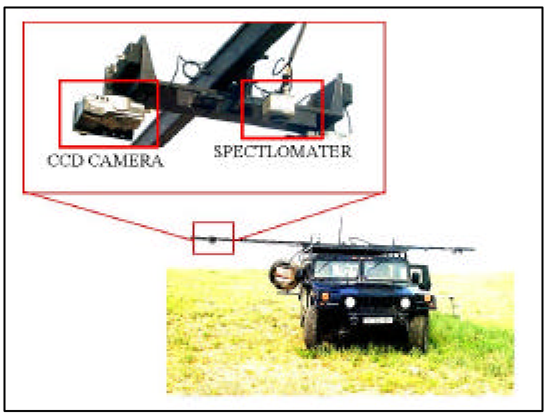

Figure 2. Observation Car

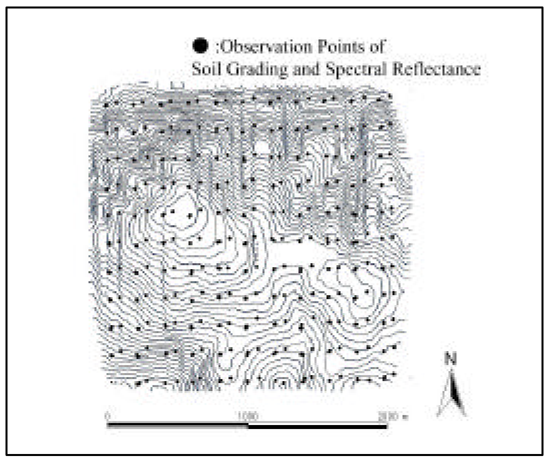

Figure 3. Observation Points of Soil Grading on Contour Map

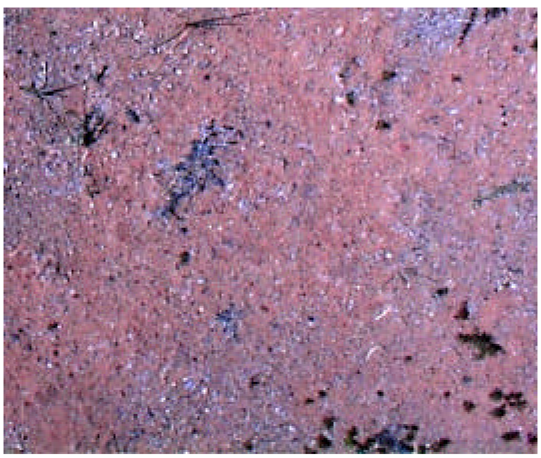

Figure 4. Instance of Soil Grading Category 1

Figure 5. Instance of Soil Grading Category 5

3.4 Used Satellite Images

In this study, Landsat 7 -ETM was used. Because Landsat 7 has short wave infrared band which can detect soil condition. Product creation time of this satellite image was October 28 1999. The image was carried out geometric correction with topographic map which generated by this ground truth.

4. RELATIONSHIP BETWEEN SATELLITE IMAGES AND TOPOGRAPHIC RESULTS FEATURE

4.1 Relationship between Soil Moisture Contents and Topography

The results of soil moisture contents were compared with slope aspect and inclination that was derived from DEM. Figure 6 shows relationship between inclination and soil moisture ratio. Figure 7 shows relationship between slope aspect and soil moisture ratio. Soil moisture had no tendency with inclination and slope aspect. So it seems that soil moisture contents might not dependence on element of topography in the test area [(3)] (A YOSHINO, 2001).

4.2 Relationship between Hill Shading and Satellite Images

The result of soil moisture observation was uniform and very small quantity in the test area. It means that soil moisture has almost same status regardless with topography. Therefore satellite image will be deeply influenced by topography because of shading. The hill shading will be related with spectral reflectance. In this chapter the shading image will be compared with the satellite image.

DEM was converted to grid type in 30 m spatial resolutions same as Landsat 7 (Figure 9). Shading value in each grid was calculated using Lambert's equation with use of DEM. Strictly, this equation needs the parameters of reflection ratio on surface and optical atmospheric thickness. However these parameters did not use in this study. Because generated shading image will just compare with satellite image statistically. Cosine value between light source vector and normal vector of the surface was used for shading image generation. Figure 8 shows derived shading image. Sun elevation and azimus were used same parameters as acquired period of Landsat7 image. Table 1 shows correlation coefficients between shading on each band. The results showed band 4, 5 and 7 have higher correlation [(1)] (A YOSHINO, 2001).

Table 1. Correlation Coefficients Between Shading Value and D.N. of ETM in Each Band of Landsat 7

Band Num.	Correlation Coef.
Band 1	0.4
Band 2	0.53
Band 3	0.65
Band 4	0.76
Band 5	0.78
Band 7	0.75

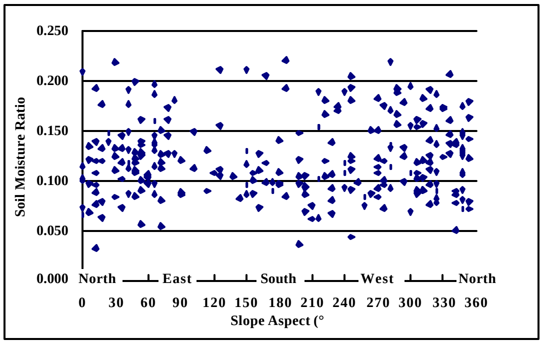

Figure 6. Relationship Between Slope Aspect and Soil Moisture Ratio

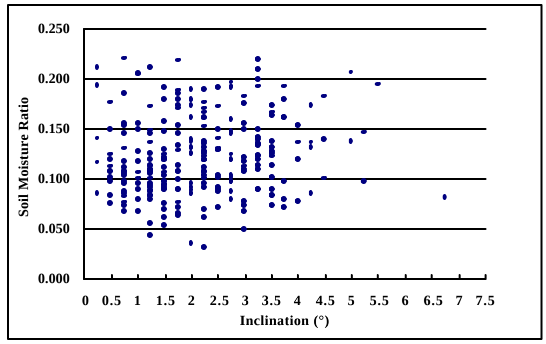

Figure 7. Relationship Between Inclination and Soil Moisture Ratio

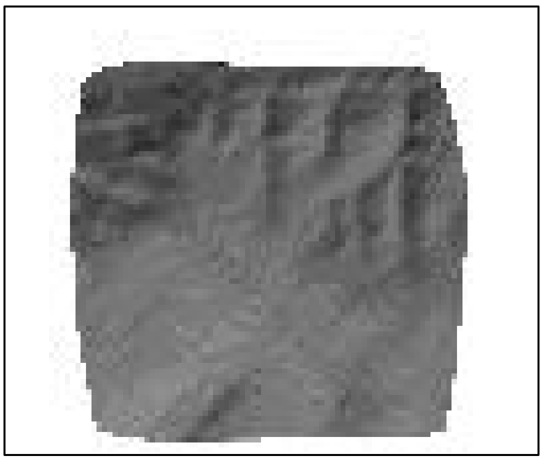

Figure 8. Shading Image

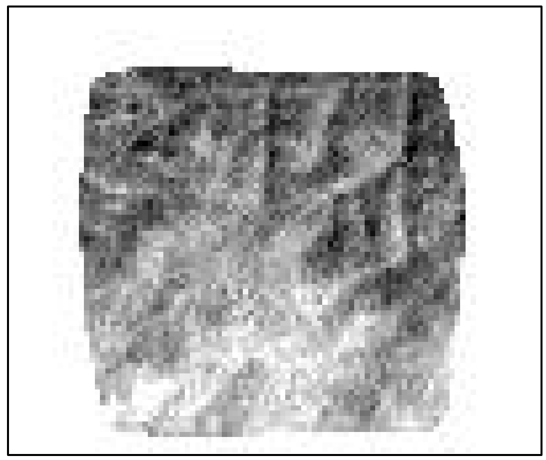

Figure 9. Geo-corrected Landsat7-ETM (Band 7)

4.3 Removing Effects of Topography

Satellite images are influenced by Topography. Figure 10 shows relationship between the shading value and D.N. of band 7. An equation of the fitting line was calculated by regression analysis. Correlation coefficients showed 0.75 (band 7). Therefore, D.N. of band 7 can be estimated by shading value using following equation.

$X = A * S + B$ ------------------------------- (Equation 1)

S: shading value

X: Estimated D.N. of band 7.

A: Gradient of regression line 2.815579 (band 7)

B: Interception of regression line -159.81 (band 7)

By using previous equation 1, topographic influence in Landsat 7 images might be eliminated. Transform can be established by following the first order equation, which uses gradient and interception in previous regression analysis.

$Y_{ij} = C_{ij} * X_{ij}$ ------------------------------- (Equation 2)

$C_{ij} = X_{max} / (A * S_{ij} + B)$ ------------------------------- (Equation 3)

Yij: After transform value in each pixel

Cij: Transform coefficient in each pixel

Xmax: Estimated maximum value

Xij: D.N. of satellite image in each pixel

Smax: Maximum value of shading

Sij: Shading value in each pixel

Figure 11 show the image removed topographic influence by using previous transform Equation 2. This image called a corrected image in this study.

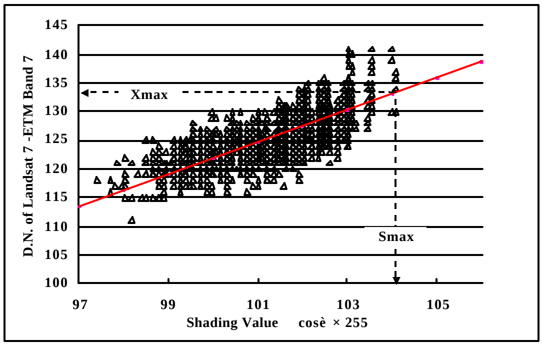

Figure 10. Relationship Between Shading Value and D.N. of Band 7

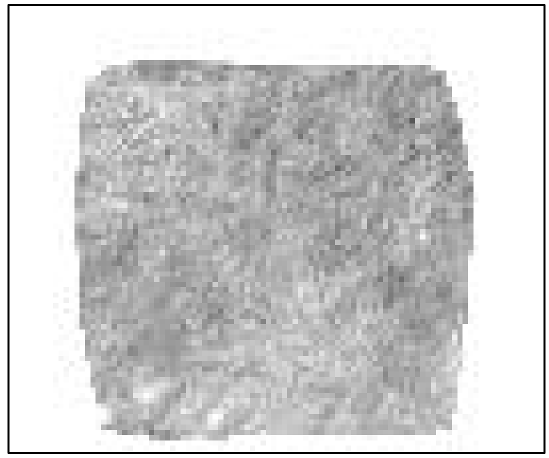

Figure 11. Removing Topographic Influence Image (Band 7)

5. RELATIONAHIP BETWEEN CORRECTED IMAGE AND SOIL CONDITION

Vegetation condition must be considered to detect soil condition from the corrected image. Therefore the corrected image compared with the vegetation and soil grading. Vegetation was estimated by NDVI using the corrected image. Average value of NDVI in corrected image was -0.031. It was very thin vegetation and almost homogeneous.

Figure 12, 13 and 14 show average value of the corrected image in each category of soil grading. Each line on the figure means tabulation result according to NDVI value. In case of low NDVI points, soil condition should be deeply influenced to the corrected image. From these figures, the value of band 7 corrected image had tendency to drop with big soil grading. The gravel might made low reflectance because of shadow by gravel-self. On the other hand, the fine sand might make high reflectance because of no shadow.

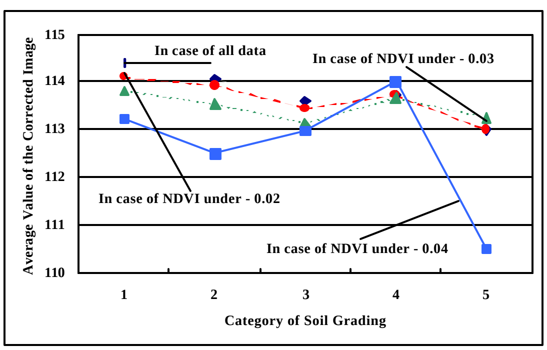

Figure 12. Average Value of the Corrected Image in Each Category of Soil Grading (Band 4)

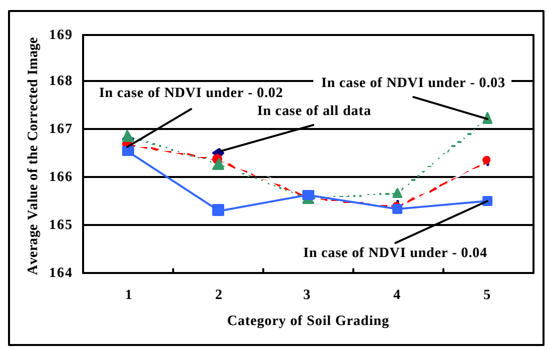

Figure 13. Average Value of the Corrected Image in Each Category of Soil Grading (Band 5)

6. CONCLUSION

Ground truth was succeeded to carry out. The soil moisture has no tendency according to topography in the test area. The influence of soil moisture can disregard in the test area for satellite image analysis. Therefore topographic influence could be easily removed from original satellite image.

In this test area, vegetation condition was very thin which average of NDVI was -0.031. And the corrected image of band 7 was efficient to detect soil grading in such thin vegetative area. Value of the corrected image had tendency to drop with big soil grading. The gravel might make low reflectance because of shadow and fine sands might make high reflectance.

As future study, satellite image of ASTER will be used. ASTER has six short wave infrared bands. It will be more efficient to detect soil condition.

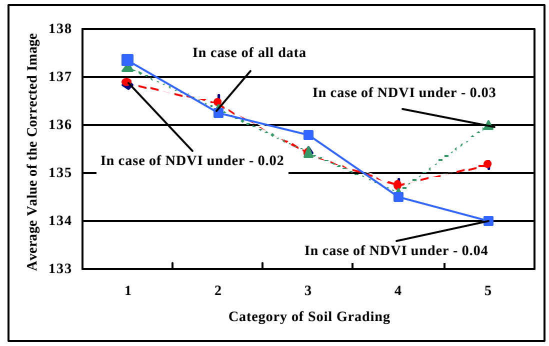

Figure 14. Average Value of the Corrected Image in Each Category of Soil Grading (Band 7)

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