Thesis for the Degree of Master of Engineering

An analysis of ecosystem change around deserts of central China and Mongolia

by

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An analysis of ecosystem change around deserts of central China and Mongolia
(중국과 몽골 사막 주위의 생태계 변화 분석)

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by
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Abstract

The purpose of this research is analyzing the ecosystem surrounding the Gobi desert in North Asia quantitatively as well as qualitatively more concretely. We used Normalized Difference Vegetation Index (NDVI) derived from VEGETATION (VGT) sensor onboard the SPOT 4 and 5 satellite during 1999~2007. Monitoring ecosystem of this area is necessary for the environment change, because the vegetation of North Asia is a hot spot in global environment change and this improved study will allow us to predict areas prone to the rapid environmental change. We classify into eight classes and compare our classified map with MODerate resolution Imaging Spectrometer (MODIS) global land cover. Three classes (barren land, shrubland and grassland) were focused on our analysis. Since there are

significant extensions of barren land from 1992 to 1999, 47.8% (1916674 pixels) of 1992's shrubland changed to barren land in 1999. Among the five terms (1999-2003, 2003-2005, 2005-2007, 1999-2005, 1999-2007), there are many changes during 1999-2003 for barren land and during 2005-2007 for shrubland and grassland. Also, forward change and backward change analysis were considered in this study between 1999 and 2007. Quantities of the positive change pixels in forward change for barren land are similar to the number of negative change pixels in backward change. For shrubland and grassland, negative change area is bigger than positive change area in both forward change and backward change. Precipitation patterns for nine years are nearly similar to our classified map. We have to keep a careful watch on the problems related to ecosystems in this area constantly.

1. Introduction

Land cover and its changes, affecting multiple aspects of the environmental system such as energy balance, biogeochemical cycles, hydrological cycles and the climate system, are regarded as critical elements in global change studies (Nemani et al., 1996 , Xue, 1996). Many researches have been made to study vegetation cover and its changes until now. Huttich et al. (2007) monitored the Northern Eurasia's land-cover change trends using SPOT VEGETION time-series from 1998 to 2005. Christopher et al. (2007) found regions in North America that experienced marked increases in annual photosynthetic capacity. Guo et al. (2007) indicated an overall warming and drying trend of the climate and common degradation tendency of the ecosystem with a greening trend. Young and Harris (2005) assessed changes in global vegetation photosynthesis during 1982-1999. Yu et al. (2003) evaluated the relationships between climate and interannual variation of the grassland boundaries in Mongolia between 1982 and 1990. Monitoring vegetation change is an important method to study the impacts of global climate change (Zhou et al., 2001, Weiss et al., 2004). Especially in arid and semiarid regions, the observation of ecosystem that are sensitive to climate change can improve an understanding of the relationships between climate and ecosystem dynamics. Vegetation is one of the earth's most vital natural resources and a mediator in climate and climate change as well. Global warming has caused variation in vegetation phenology and productivity and has inflicted considerable damage. Therefore, there is a pressing need to assess and predict the potential influence of global change on vegetation ecological systems

The climate of North-East Asia (China and Mongolia) has undergone significant changes over the last 30 years (Chase et al., 2000). The Mongolian steppe and the fertile Northeast China Plain are among the most productive agricultural regions of the world, but there are many chance of desertification in the future. Effective measures will be introduced to conserve vegetation in this area. The ecosystems found in this region are sensitive to climate and land use changes. Changes in land use have the potential to alter regional climate dynamics (Fu and Wei 1993, Fu 1994). In addition, grassland conversion to cropland has led to increased erosion and desertification in the more arid portions of the region. It is apparent that climatic factors and humans activities have affected its vegetation. Therefore, monitering the Asia's ecosystems is essential for our global vegetation protection and we have to regard on the problems related to ecosystems in this area internationally.

Differentiation of annual, inter-annual and long-term phenological patterns are an important component of global ecosystems monitoring and modeling (Reed et al., 1994, Schwartz, 1999) and may lead to better understanding of how and why land cover changes over time. Time series of remotely sensed data are an important source of information for understanding land cover dynamics (Bethany et al., 2006). To infer north east Asia vegetation changes we used Normalized Difference Vegetation Index (NDVI) data derived from SPOT VEGETATION during 1999-2007. The Advanced Very High Resolution Radiometer (AVHRR) NDVI is frequently referred to by many researchers due to its long observation sequence since the late 1970s, and SPOT/ VGT has a number advantages over AVHRR, including more spectral bands that can be used for vegetation analyses these days. Remote sensing has the ability to detect land cover change because any variation on the surface of the Earth will result in radiance detected by sensors at different times. Timely and accurate change detection of vegetation offers understanding to better manage and use resources.

The aim of this study is analyzing the ecosystem surrounding the Gobi desert in North Asia quantitatively as well as qualitatively more concretely. Monitoring ecosystem of this area is essential for examining the environment change, because the vegetation in North-Asia is a hot spot in global environment change and this improved study will allow us to predict areas prone to rapid environmental change. Also it is useful for future land use planning purpose.

2. Data and methods

2.1 Data

The study site (Fig. 1) covers an area from 73°37′E to 120°41′E in longitude and from 30°81′N to 52°31′N in latitude (2409×5270km, 12695430 km^2). The land cover types vary greatly in this vast area, including evergreen forest, deciduous forest, cropland, shrubland, grassland, and barren deserts like the Gobi Desert. Land cover variability is strongly influenced by the monsoon climate system. The majority of annual precipitation falls in the warm summer season in association with the arrival of the monsoon. Summer is also the time of the critical growing season when vegetation activity is at its maximum.

For this research, we use two kinds of main data. The first data is the Normalized Difference Vegetation Index (NDVI) derived from VEGETATION (VGT) sensor onboard the SPOT 4 and 5 satellite and the other one is standard monthly precipitation of the NOAA Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP).

Over the last two decades, many studies of land cover and it's variation have explored data from the Advanced Very High Resolution Radiometer (AVHRR) sensors (Lee et al., 2002, Liu et al., 2003). However, the AVHRR sensors, originally designed for meteorological applications, have only two spectral channels (red and near infrared) that are related to vegetation and phenology (Xiao et al., 2002). Since the satellite component of the program be launched in March 1998 onboard SPOT 4 and 5, many users have accessed to VGT Program and utilized for land cover change trend. Unlike scanner sensors (e.g.AVHRR), the VGT instrument uses the linear-array technology and thus produces high-quality imagery at coarse resolution with greatly reduced distortion

The VGT data set included four spectral bands(blue, red, NIR, MIR) (table 1). Two levels of enhanced products are available to users: P products correspond to data which be mostly used by physicists for methodological development that could be embedded into applications using VEGETATION data and S products where some synthesis is applied on the "Core Archive" data to provide ground reflectance as well as some simply derived parameters. S products are composed by 2 products: The daily synthesis (S1) and the 10-day synthesis (S10). S1 products provide the surface reflectance obtained after pre-processing, such as, geometric and atmospheric corrections. The geometric accuracy is less than 0.3 pixel for local distortion. Pixels are sampled using uniform grid spacing, allowing to correct distortion for inter-band registration, satellite orbit, attitude and elevation. S10 is computed from all the passes on each location acquired during 10-day periods. The periods are defined according to the legal calendar: from 1st to 10th, from 11th to 20th, from 21st to the end of each month. A

10-day synthesis (S10) based on the selection of the "best" measurement of VGT-S1 pixels on the entire period. The selection is based on the Maximum Value Composite (MVC) approach for NDVI, as it is commonly accepted today, even if many problems associated to that selection are identified. This technique helps minimize the effect of variability in atmospheric optical depth and eliminate most cloudy pixels. 321 synthetic images on 10-day basis (S10 product) acquired for 9 years (from January 1999 to November 2007) were used in our study. The data are being received by the Kiruna station (Sweden), processed and archived by the VITO production center located in Belgium and distributed by SPOT-Image.

The standard monthly precipitation was provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.cdc.noaa.gov/. The empirical basis of the work consists of the NOAA Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP) data. The spatial coverage of global monthly precipitation is 2.5 degree latitude-longitude grid from 1979 to 2007. We changed the monthly precipitation to total yearly precipitation to compare with each yearly pattern of vegetation classification.

MODIS global land cover was used as reference set to compare our classified map for accuracy assesment. (Fig. 2). Boston University prepared the MODIS land cover data using MODIS 1-km data on board the Terra satellite (Friedl et al., 2002). The

MODIS Land Cover Product supplies an International Geosphere-Biosphere Programme Data and Information System (IGBP-DIS) land cover classification map of the globe. They also provide 14 classes University of Maryland (UMd) global land cover scheme and etc. for ease use by the community.

We used UMd 1km global land cover maps as vegetation classification in 1992 (Fig. 3). The UMd land cover used the data derived from the National Oceanic and Atmospheric Administration (NOAA) AVHRR satellite sensor from April 1992 to March 1993 inclusive. As know in fig. 2 and fig. 3, MODIS land cover and UMd land cover have same class legend. Table 2 shows a consist of UMd and MODIS land cover in study area. Percentage of shrubland in UMd land cover nearly doubled what it was in MODIS land cover

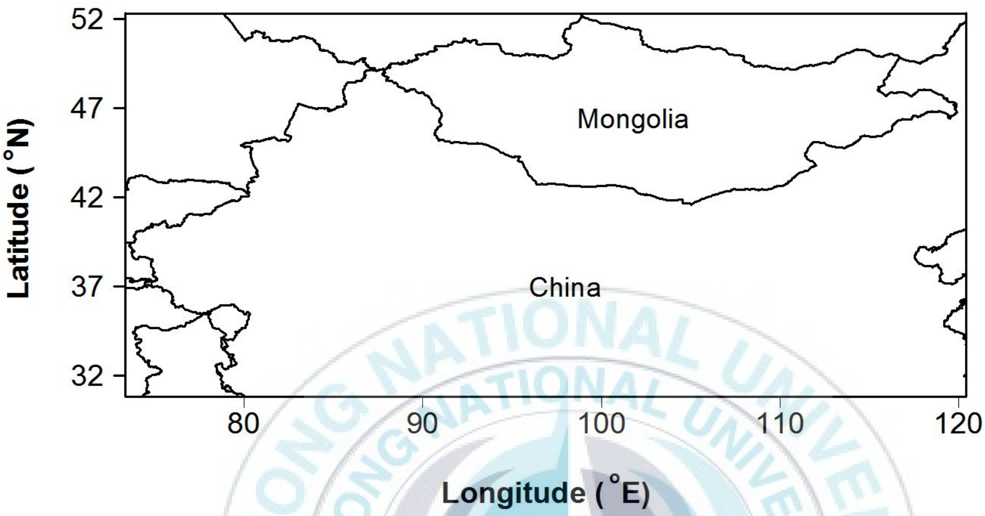


Fig. 1. Location of study area

Table 1. Spectral characteristics of SPOT VEGETATION sensor

Spectral Bands	Wavelength	Surface reflectance range
BLUE	0.43-0.47㎛	0.0-0.5
RED	0.61-0.68㎛	0.0-0.5
NIR	0.78-0.89㎛	0.0-0.7
SWIR	1.58-1.75㎛	0.0-0.5

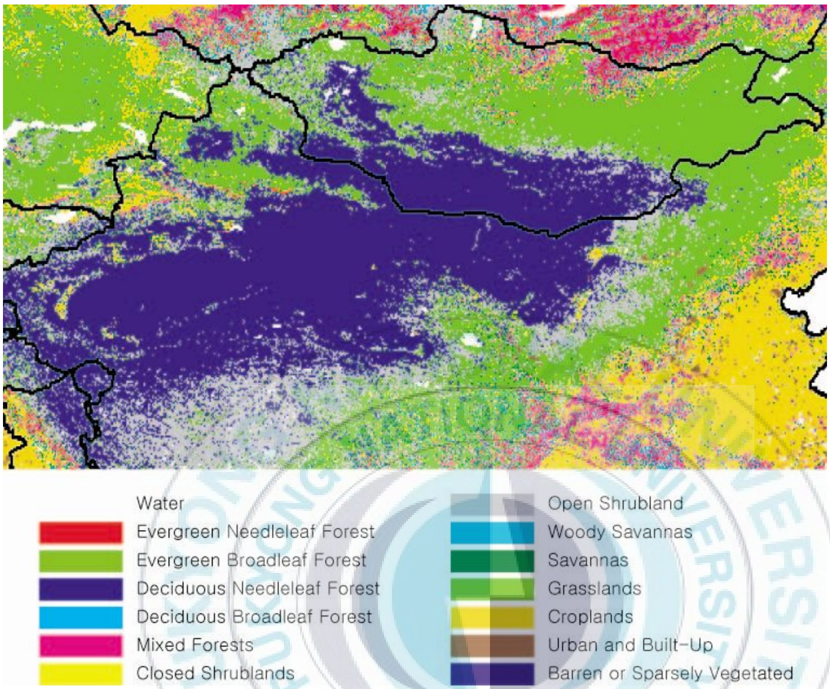


Fig. 2. MODerate resolution Imaging Spectrometer (MODIS) global land cover (MODIS land cover)

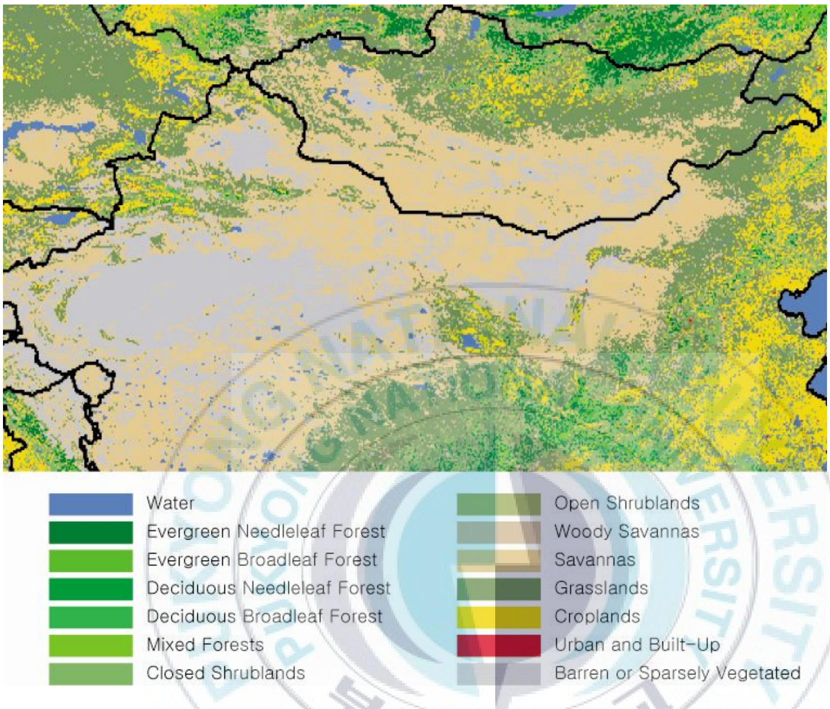


Fig. 3. UMd (University of Maryland) 1km global land cover maps

Table 2. Consist of University of Maryland (UMd) and MODerate resolution Imaging Spectrometer (MODIS) land cover

Class legend	class (%)	
	UMd land cover map	MODIS land cover map
barren land	12(16.65)	16(28.55)
shrubland	8(1.71),9(29.03)	6(0.39),7(14.25)
grassland	10(23.50)	10(31.84)

2.2 Method

2.2.1 NDVI Correction

We use NDVI from SPOT/VGT from 1999 to 2007. Although 10-day composite SPOT NDVI data are generated using the MVC approach which helps minimize the effect of variability in atmospheric optical depth and eliminate most cloudy pixels, data analysis remains affected by the residual effects of sub-pixel clouds, prolonged cloudiness, persistent haze, and bidirectional reflectance variation. We identify these contaminated NDVI pixels using 5^{th} polynomial regression function. First process is comparing NDVI with newly produced NDVI that was derived from 5^{th} polynomial regression coefficients. Then, we choose a higher NDVI value between newly reproduced NDVI using 5^{th} polynomial regression and original NDVI. If newly reproduced value is lower than non-processed NDVI, we choose a non-processed NDVI because the higher value considered true. After comparing all of two NDVI, 1-th reproduced NDVI value was determined by choosing higher value NDVI. Then 1-th reproduced NDVI was again performed using 5^{th} polynomial regression. Those processing was iterated 7 times, because 7 times processing were optimized for identification of contaminated pixels in previous study. Fig. 4 shows the result of NDVI correction of any pixel in study area.

The corrected NDVI has the higher value than non-corrected NDVI. These corrections of NDVI profile improved the quality of classification.

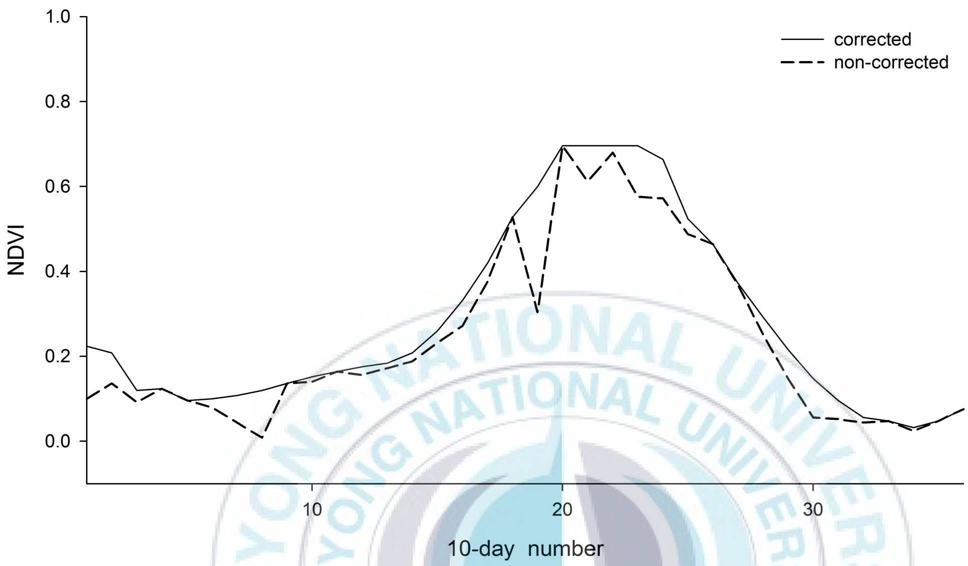


Fig. 4. Comparison of the corrected NDVI time series with original NDVI time series in 2000

2.2.2 Classification

Unsupervised classification was carried out using the ISODATA method of the ERDAS software. Probably the most common unsupervised classification scheme is the Iterative Self-Organizing Data Analysis Technique (ISODATA). ISODATA is an iterative unsupervised classification scheme. It has been developed with empirical knowledge gained through experimentation and requires relatively little in the way of human interaction. While implementations of ISODATA vary there is often some nominal inputs that need to be specified by the users. A convergence threshold of 95% and 10 as the maximum number of iterations were assigned. The initial number of classes is fixed 8.

Fig. 5 shows the result of classification for 9 years (1999-2007). There are similar patterns of classification for study terms, but we can detect some change of vegetation distribution.

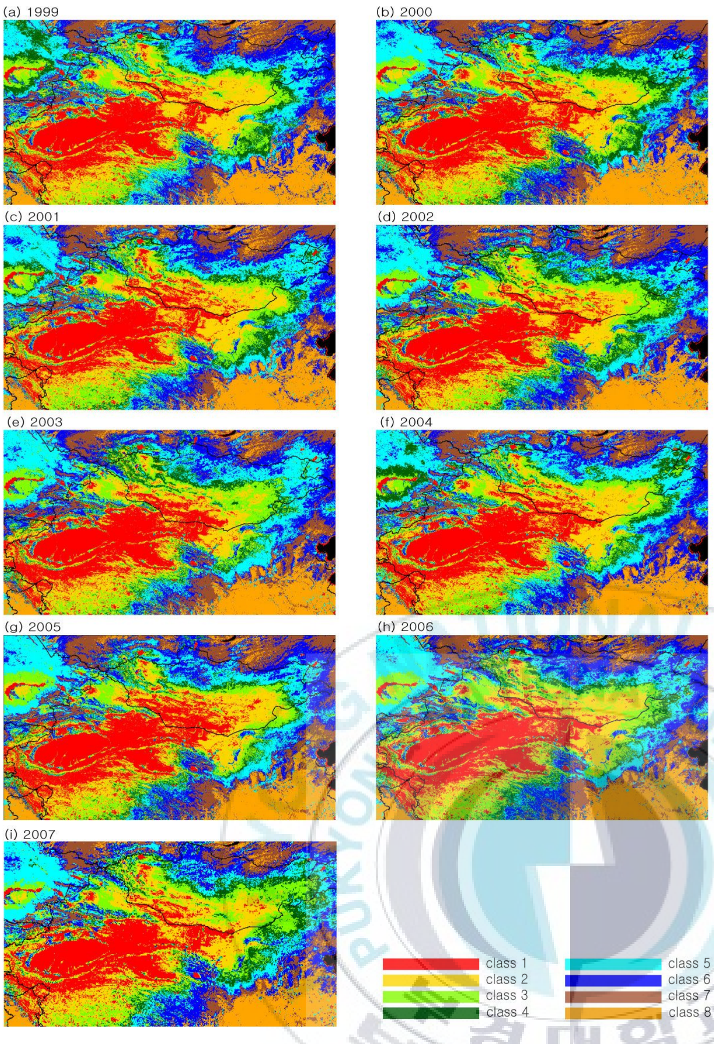


Fig. 5. Result of Classification from 1999 to 2007 using unsupervised classification method

3. Result

3.1 Analysis of NDVI time series

Fig. 6 shows NDVI time series of 2001 for eight classes. This NDVI time-series of the 10-day composites indicates a distinct seasonal pattern for different vegetation types. The NDVI values of class 1 and class 2 are significantly lower than other classes and have the least variation in the amplitude as barren areas while NDVI of vegetated areas began to increase in May and decreased in October with a peak in July and August. Class 8 with two harvests showed more than one NDVI peak while all other vegetation classes had only one peak.

Although the same class has the similar features of NDVI time series for each of selected study period, there are a little bit of inter-annual differences. Fig. 7 shows these variables for eight classes. That seems to relate to vary climatic environment.

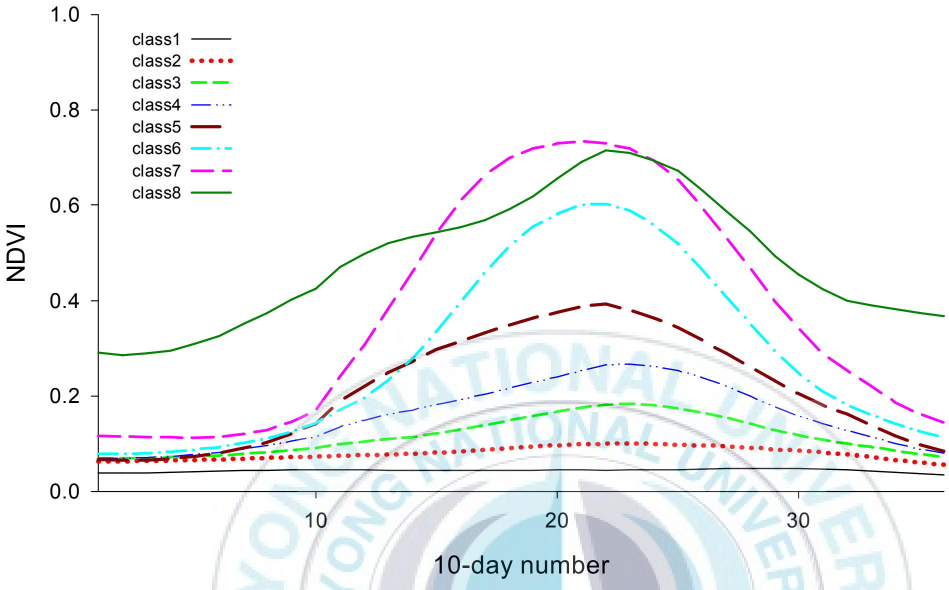
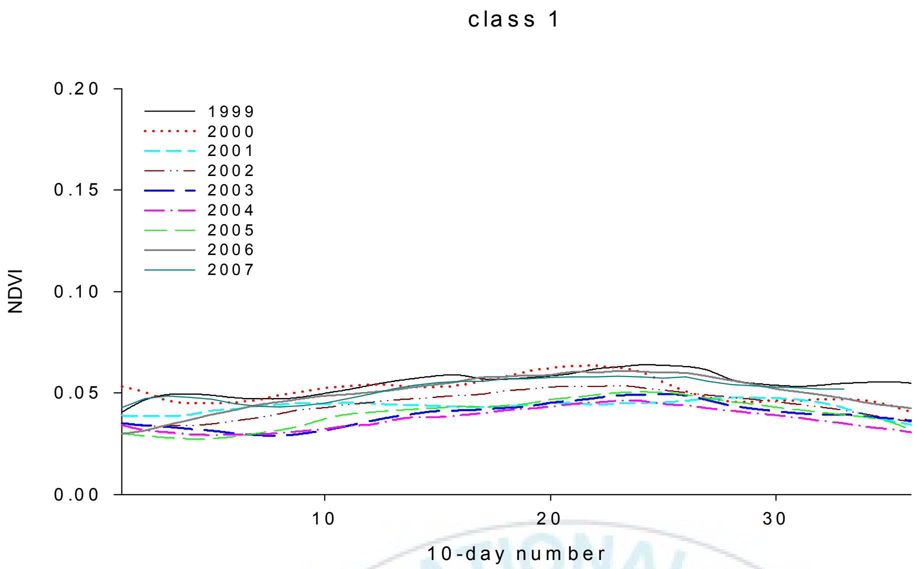


Fig. 6. Time series of NDVI profile in 2001

(a)



(b)

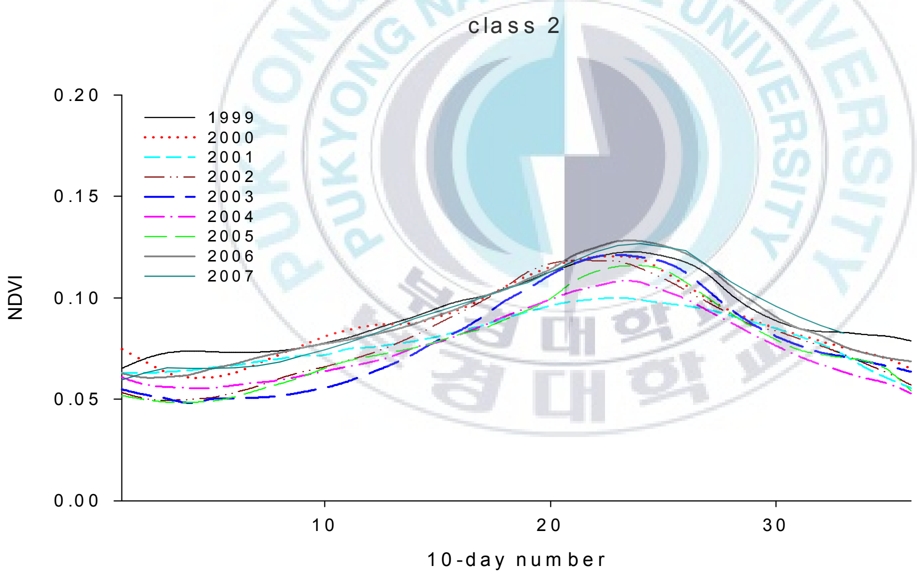
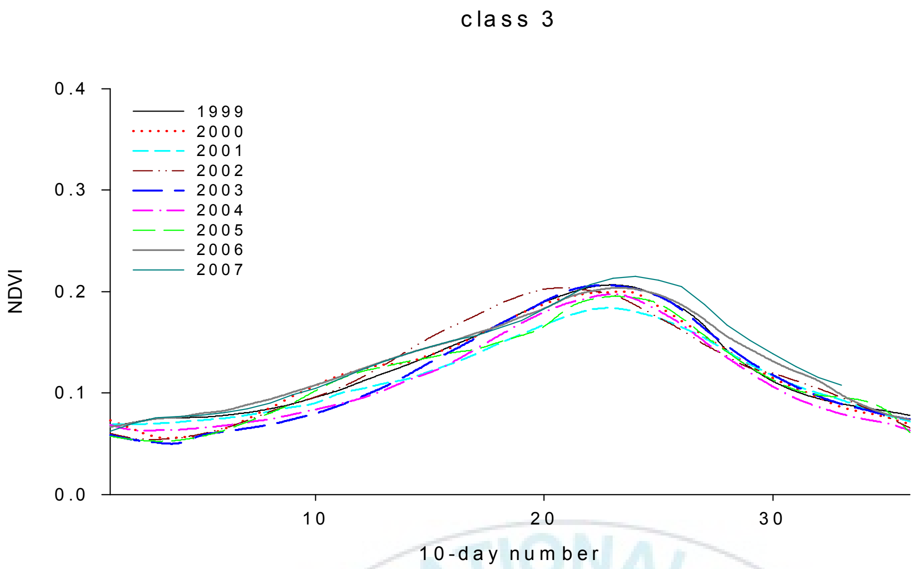


Fig. 7. NDVI time series of 9 years for (a)class 1; (b)class 2; (c)class 3; (d)class 4; (e)class 5; (f)class 6; (g)class 7; (h)class 8

(c)



(d)

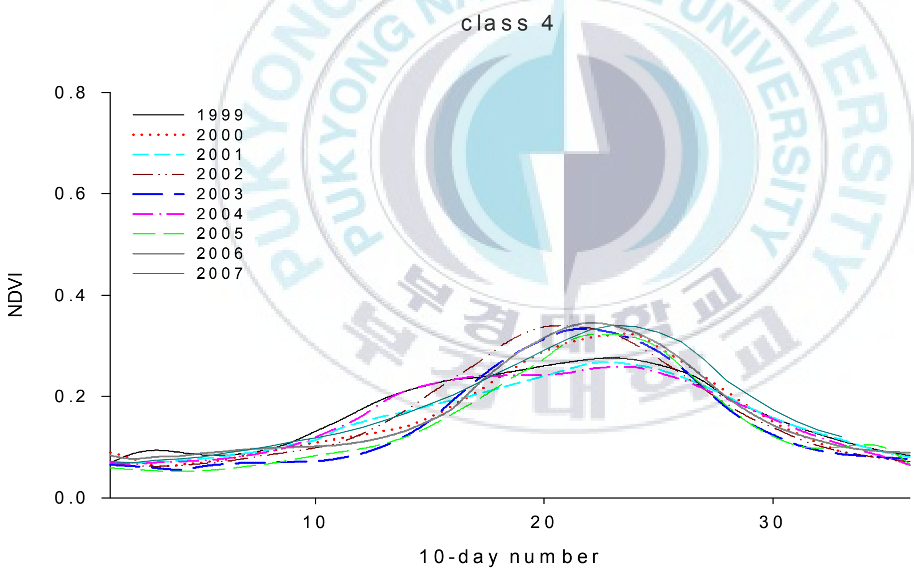
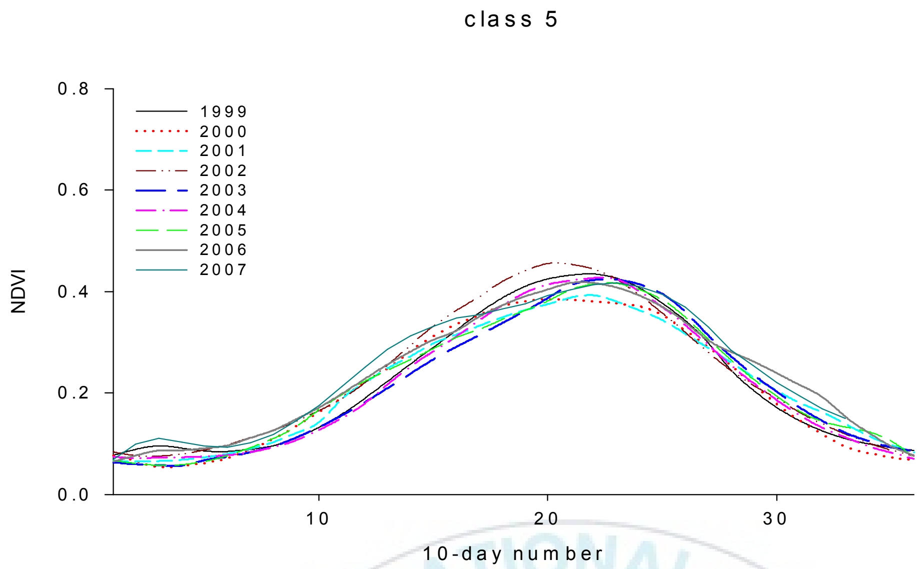


Fig. 7. Continued

(e)



(f)

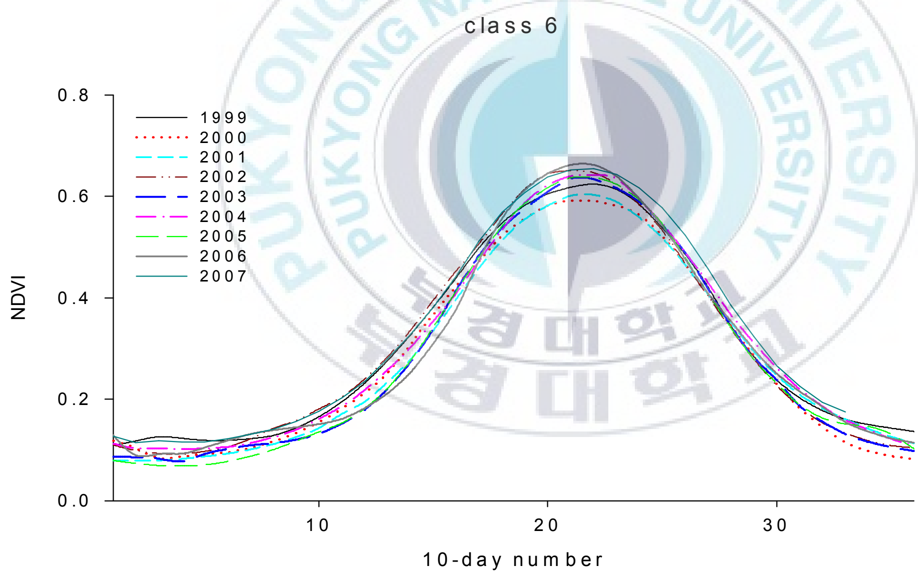
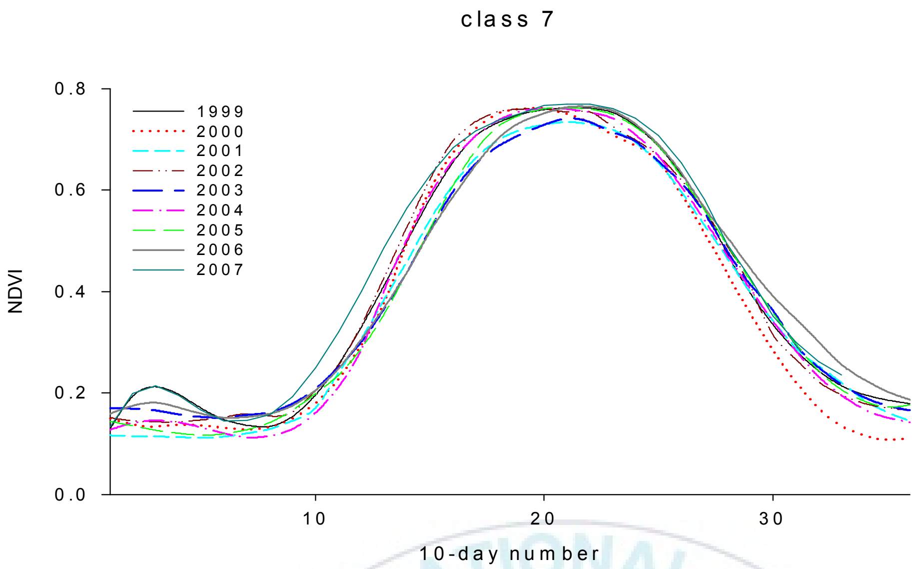


Fig. 7. Continued

(g)



(h)

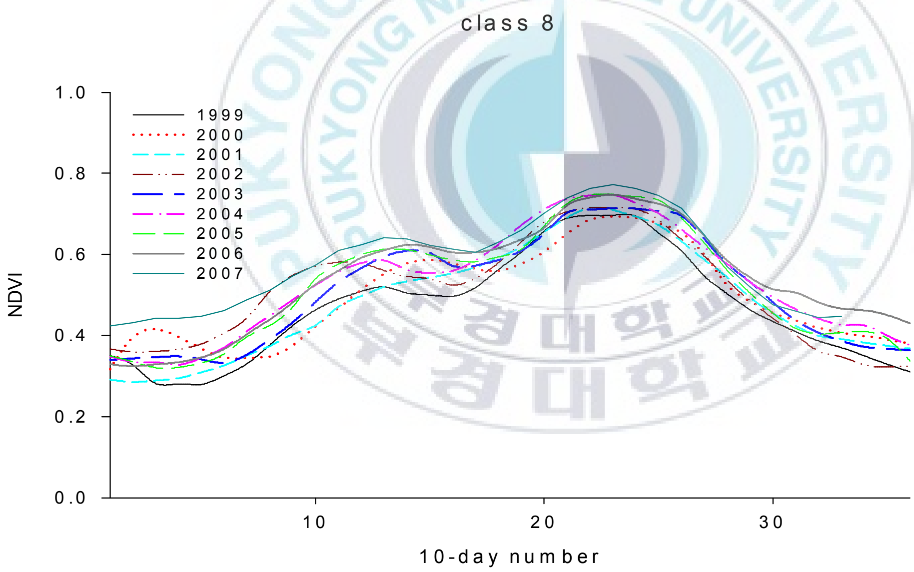


Fig. 7. Continued

3.2 Comparison of our classification with MODIS land cover

Many kinds of global land cover are currently available, MODIS global land cover, Global Land Cover (GLC) 2000, UMd (University of Maryland) 1km global land cover maps, International Geosphere-Biosphere Programme Data and Information System (IGBP-DIS) land cover, etc. There are some discordance among these global land covers (Hansen and Reed, 2000). It seems that the disparity is caused by different satellite data, classification method and class categories. Our objective isn't complete of land cover and improvement of land cover accuracy. Our goal is just monitor changes over the ecosystem surrounding the Gobi desert in Asia. In order to find these variations, classification analysis of vegetation is obvious method of change detection and class labeling is needed for class definition.

Our classification results were compared to MODIS global land cover. MODIS data sets were acquired from 15 Oct. 2000 to 15 Oct. 2001, so we compared 2001 classification with MODIS land cover. Nearly over 70% of Class 1 and 2 is consisted of barren or sparsely vegetated. Especially, class 1 has high correspondence as 95.48%. Major component of class 3 is open shrubland of 45%. Agreement for class 4 and 5 are 72.6%, 78.8%, respectively (Table 3). According to this results, class 1 and 2 are regarded as barren land: class 3 is regarded as shrublands: class 4 and 5 are regarded as grasslands: other classes are regarded as etc. We just focus on barren land, shrubland and grasslands, so these etc. was excepted for our analysis.

Table 3. A comparative table of our classified class of 2001 with MODIS land cover

Newly classified class of 2001	Major class in MODIS-2001*(%)		
class1	16(95.48%)		
class2	16(74.73%)	7(19.90%)	
class3	7(45.23%)	10(38.70%)	16(15.61%)
class4	10(72.63%)	7(21.13%)	16(4.31%)
class5	10(78.86%)	7(10.63%)	
class6	10(53.75%)	12(23.59%)	7(12.53%)
class7	12(27.79%)	5(21.87%)	10(19.42%)
class8	12(53.93%)	5(21.66%)	

*0:Water 1:Evergreen Needleleaf Forest 2:Evergreen Broadleaf Forest 3:Deciduous Needleleaf Forest 4:Deciduous Broadleaf Forest 5:Mixed Forest 6:Closed Shrubland 7:Open Shrubland 8: Woody Savannas 9:Savannas 10:Grasslands 12:Croplands 13:Urban and Built-Up 16:Barren or Sparsely Vegetated

3.3 Relationship between our classification and precipitation

Vegetation change is related to climate factor such as temperature and precipitation. Many studies have explored the relationship between variability of vegetation and climate data (Fangfang et al., 2003, Sudipta and Kafatos 2004, Maselli 2004 and Mingguo et al., 2006). Fig. 8 shows the total yearly precipitation patterns of each year (1999-2007). These patterns of precipitation are similar to our classification results. It is apparent that vegetation activities are affected by precipitation. There are little of rainfall around China's Gobi desert. Fig. 9 shows the inter-annual variations of average NDVI including total classes and total yearly precipitation per pixel. There is an increase of average NDVI value after 2005. The annual precipitation of 1999 is the least one for nine years. We didn't find any obvious link between variation of average NDVI and precipitation about the hole study area. Analysis of small scale is needed to find relation with precipitation.

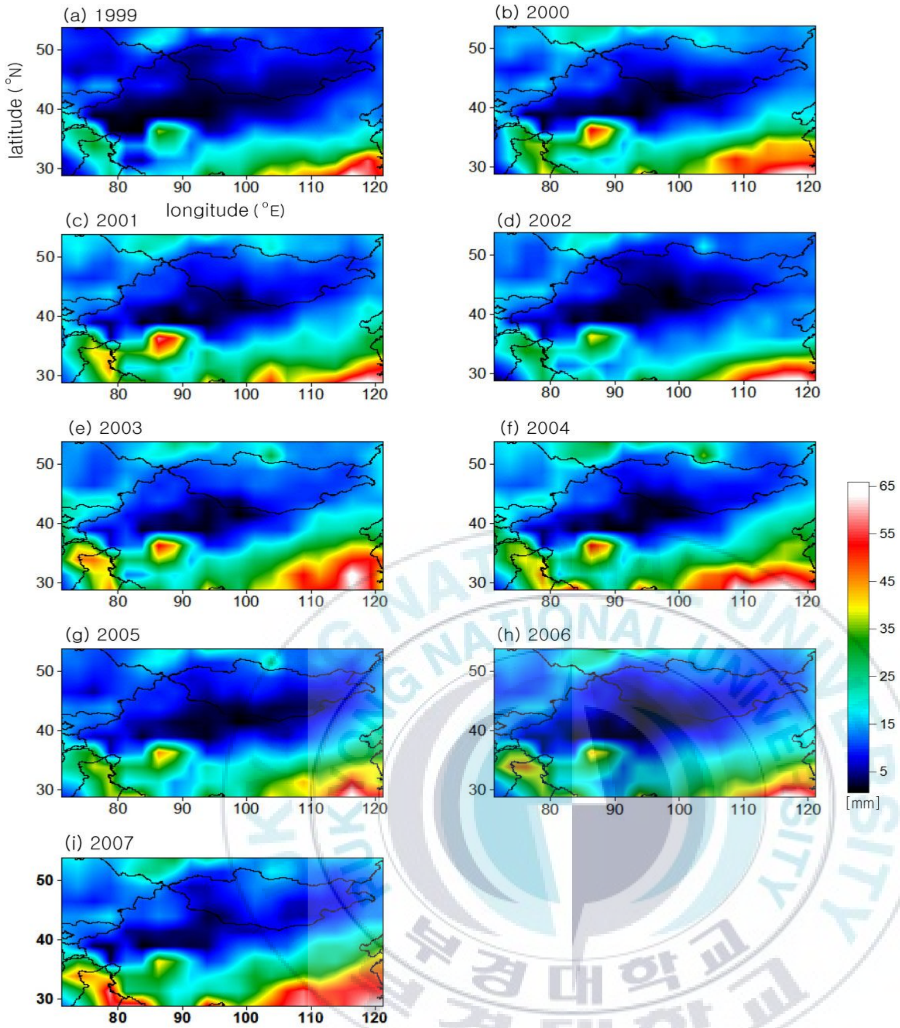


Fig. 8. Total yearly precipitation pattern from 1999 to 2007

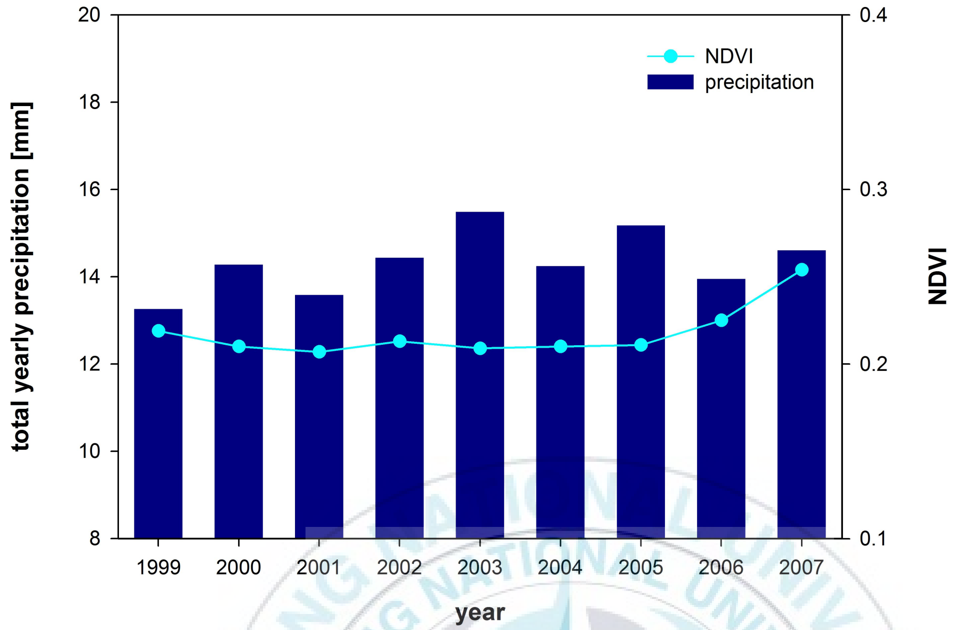


Fig. 9. Profile of yearly average NDVI and total yearly precipitation.

3.4 Trend analysis of vegetation change

It was analyzed for five terms that are from 1999 to 2003, from 2003 to 2005, from 2005 to 2007, from 1999 to 2005 and from 1999 to 2007 (Table 4-8). We separate positive and negative changes from all of changes through confusion matrix method. For example, if the higher class of prior year (1999) changed to the lower class in 2003, that are regarded to negative changes and the lower class of prior year (1999) changed to higher class in 2003, that are considered to positive changes by contraries (Table 4). Also, we compare area of negative change with area of positive change during the study terms. There are the most low correspondence of 87.5% for 2003/2005 in barren land (table 4) and 49.8% for 2005/2007 in shrubland (table 5) and 72.6% for 2005/2007 in grasslands (table 6). Low correspondence means there are many changes during above mentioned terms for each class. A remarkable things about shrubland for 1999/2003 is positive change percentage (25%) is higher than negative change one (13.3%), whereas positive change percentage is lower than negative change percentage about barren land and grasslands for all of analysis terms.

Fig. 10 shows profiles of annual NDVI mean and percentage change for each class over nine years. In barren land, rise and fall of annual average NDVI and percentages was repeated (Fig. 10(a)). There are the smallest area of barren land in 2003 and the biggest area of barren land in 2005. It seems this condition of area has relations with total yearly precipitation. There are the highest rainfalls in 2003 (Fig. 9).

For shrubland, areas of around 2% have increased for 1999/2007 (Fig. 10(b)). Unlike there are the biggest area of barren land in 2005, there are the smallest area of shrubland in 2005. We considered some shrubland of 2004 changed to barren land in 2005. There are some correspondence between average of NDVI change and percentage variation. In annual average of each year NDVI value, the graph has similar aspect like percentage change (Fig. 10 (b)). If NDVI value increases, the area of each class is rise in general. It is explain that some positive change occur at once in average NDVI as well as area, but also negative change has the same way. Grassland also have undergone various changes. Like shrubland, there are the smallest area of grassland in 2005 (Fig. 10(c)).

Also, we compare classification of 1999 with UMd land cover. The UMd land cover used the data derived from the National Oceanic and Atmospheric Administration (NOAA) AVHRR satellite sensor from April 1992 to March 1993 inclusive, so this comparison is for finding changes between 1992 and 1999. There are nearly 15% increases of barren land and 20% decreases of shrubland for 1992/1999 (Fig. 11). According to table 9, 1916674 pixels (47.8%) of 1992's shrubland changed to barren land in 1999. It was considerable changes between 1992 and 1999.

164941 pixels (12.8%) of 1992's barren land and 111039 pixels (8.64%) of 1992's grass land changed to shrubland in 1999. 765933 pixels (31.2%) of 1992's shrubland changed to grass land in 1999.

Table 4. Analysis of changed class between 1999 and 2003 through confusion matrix

1999	2003			
	barren land	shrubland	grasslands	etc.
barren land	94.98	25.00	0.89	0
shrubland	4.85	61.74	8.66	0.01
grasslands	0.17	13.19	77.63	7.64
etc.	0	0.07	12.82	92.34

positive change negative change

Table 5. Analysis of changed class between 2003 and 2005 through confusion matrix

2003	2005			
	barren land	shrubland	grasslands	etc.
barren land	87.48	11.92	0.16	0
shrubland	11.18	59.71	6.25	0.01
grasslands	1.34	28.32	84.36	9.13
etc.	0.01	0.06	9.23	90.86

positive change negative change

Table 6. Analysis of changed class between 2005 and 2007 through confusion matrix

2005	2007			
	barren land	shrubland	grasslands	etc.
barren land	94.93	24.96	1.58	0.01
shrubland	4.64	49.80	9.03	0.01
grasslands	0.38	24.40	72.58	3.81
etc.	0.00	0.83	16.81	96.18

positive change negative change

Table 7. Analysis of changed class between 1999 and 2005 through confusion matrix

1999	2005			
	barren land	shrubland	grasslands	etc.
barren land	90.90	13.68	0.37	0.01
shrubland	8.31	60.23	8.14	0.02
grasslands	0.79	26.05	80.43	8.89
etc.	0.00	0.04	11.05	91.07

positive change　negative change

Table 8. Analysis of changed class between 1999 and 2007 through confusion matrix

1999	2007			
	barren land	shrubland	grasslands	etc.
barren land	92.70	18.55	0.77	0.03
shrubland	6.71	54.02	7.33	0.04
grasslands	0.53	26.05	74.37	7.17
etc.	0	1.68	17.52	92.76

positive change negative change

(a)

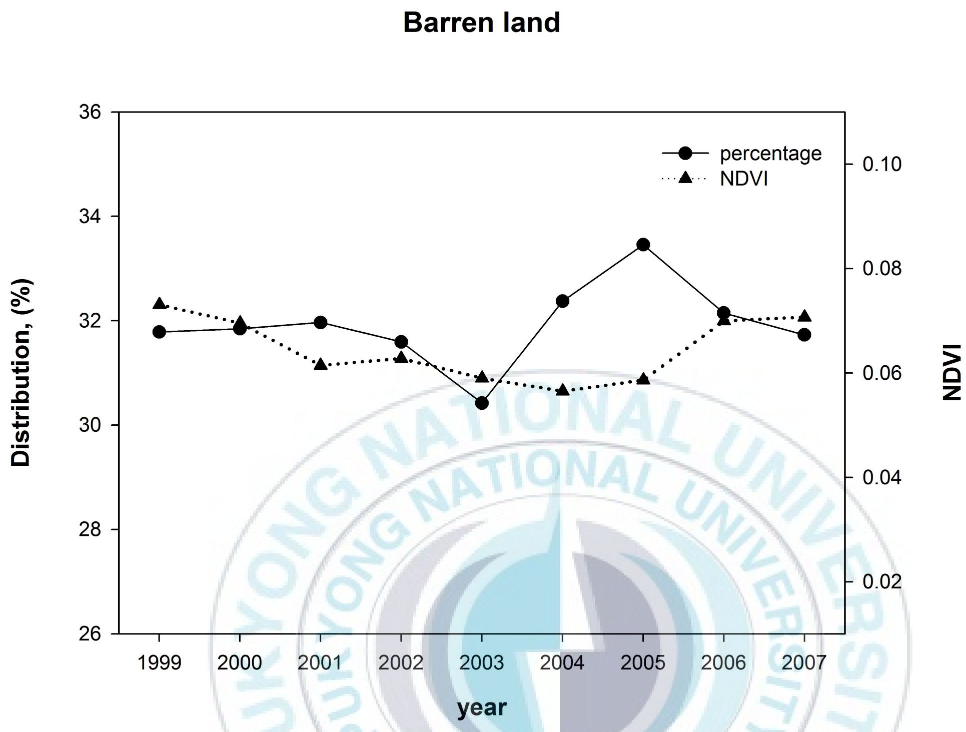


Fig. 10. Change of annual NDVI mean and percentage for (a)barren land; (b)shrubland; (c)grassland

(b)

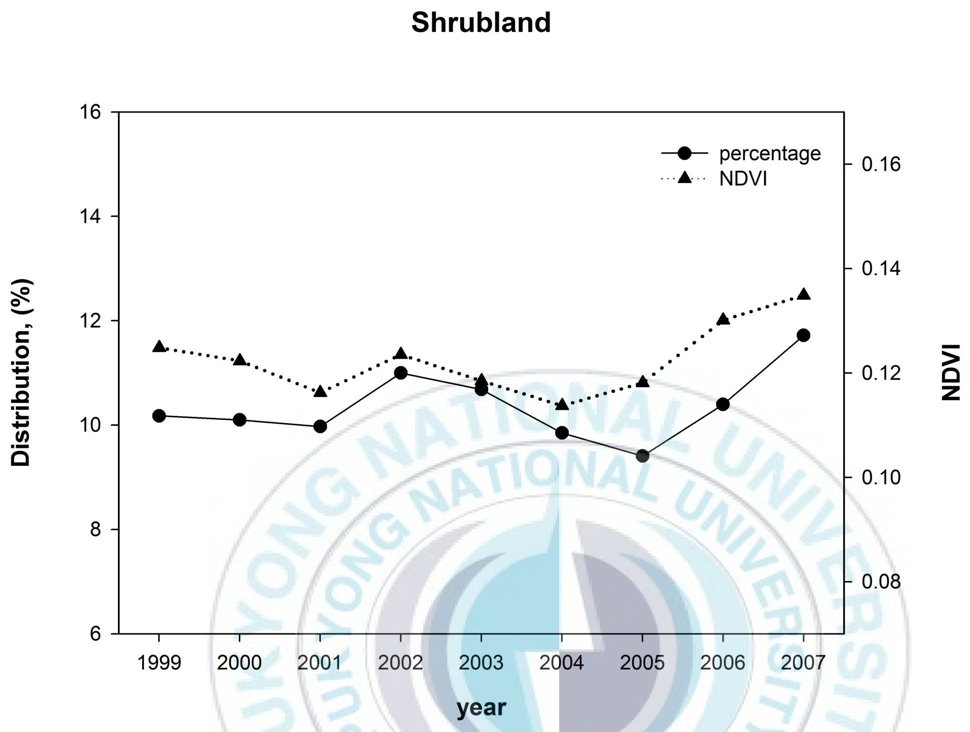


Fig. 10. Continued

(c)

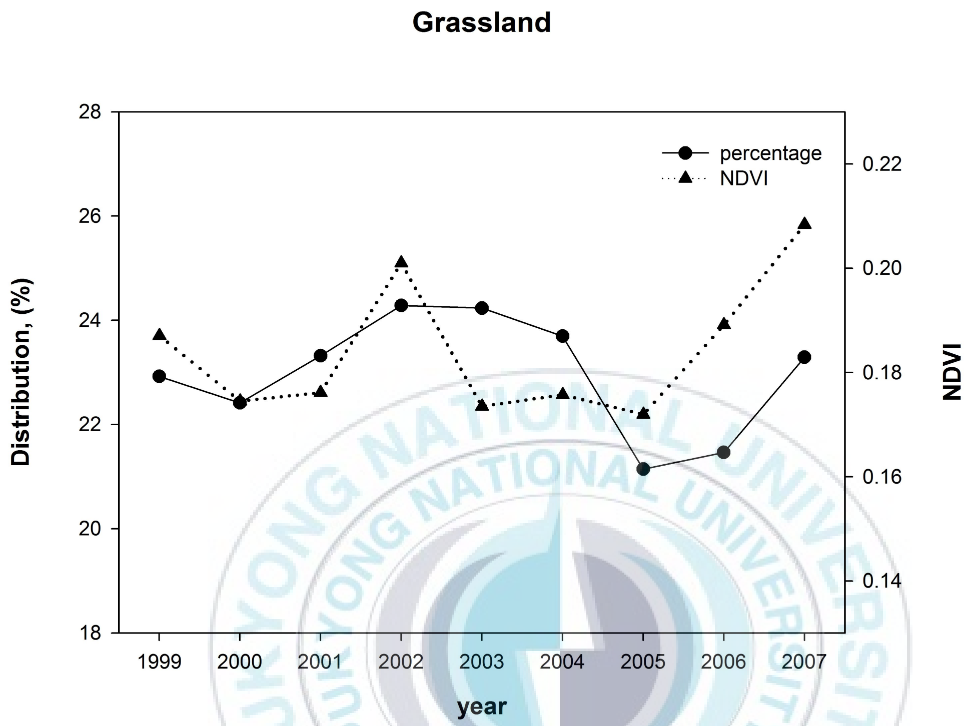


Fig. 10. Continued

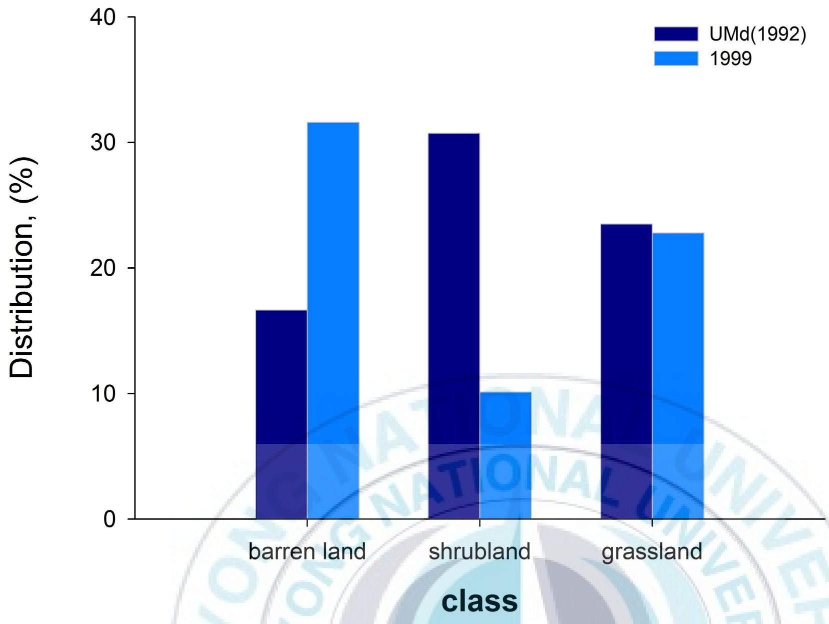


Fig. 11. Comparison of class distribution between 1992 (UMd) and 1999

Table 8. Analysis of changed class between 1992 and 1999 through confusion matrix

1992 (UMd land cover)	1999		
	barren land	shrubland	grassland
barren land	48.18	12.84	0.52
shrubland	47.78	76.67	31.17
grassland	0.62	8.64	60.40

3.5 Forward change and backward change analysis

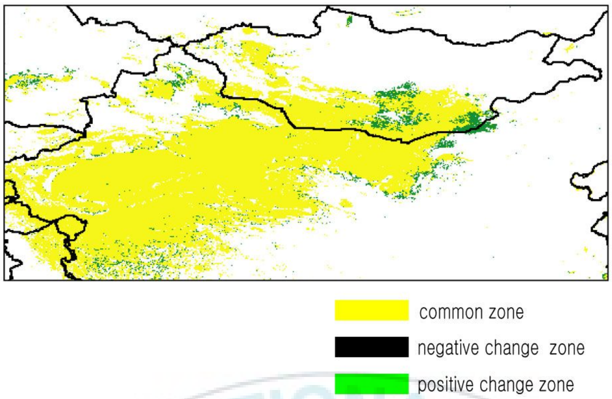
Many change detection techniques have been developed. Image differencing, vegetation index differencing, principal component analysis (PCA) and post-classification comparison are used for the most common methods of change detection. In recent years, spectral mixture analysis, artificial neural networks and integration of geographical information system and remote sensing data have become important techniques for change detection applications (Lu et al., 2003). Unsupervised change detection method was applied in this study. This algorithms selects spectrally similar groups of pixels and clusters date 1 image into primary clusters, then labels spectrally similar groups in date 2 image into primary clusters in date 2 image, and finally detects and identifies changes and outputs results (Lu et al., 2003).

There are marked change in the Gobi desert and the surrounding regions between 1999 and 2007. Some variation from one class to the other class includes positive change as well as negative change. Positive change indicate increases in NDVI during the time period and negative values indicate decreases. That means if some barren land pixel of 1999 changes to more higher class such as shrubland or grassland in 2007, this variation is positive change. We analyzed these positive and negative changes by two cases: forward change and backward change analysis is considered in this study to detect the vegetation change specifically. For instance, when some class of 1999 was altered to the other class in 2007, changed class in 2007 will be analyzed. This process is a kind of forward change analysis. On the contrary, backward change analysis is analyzing what some class of 2007 was in 1999.

Fig. 12-14 show forward change analysis in each class (barren land, shrubland and grassland) and fig. 15-17 show backward change analysis. It is possible to find a place of positive and negative change zone (Fig. 12(a)-17(a)). Three zone is presented including common zone (Fig. 12-17). Common zone is area of no change between 1999 and 2007. It is expressed how many classes move to the others (Fig. 12(b)-17(b)).

Quantities of the positive change pixels in forward change analysis for barren land (Fig. 12(b)) is similar to the number of negative change pixels in backward change analysis (Fig. 15(b)). For shrubland and grassland, negative change area is bigger than positive change area in both forward change and backward change.

(a)



(b)

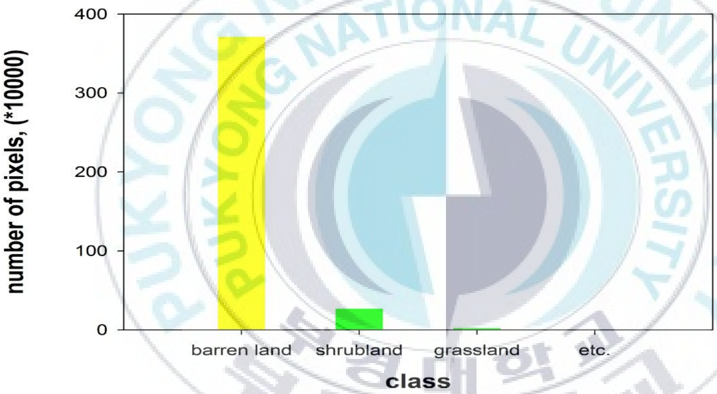
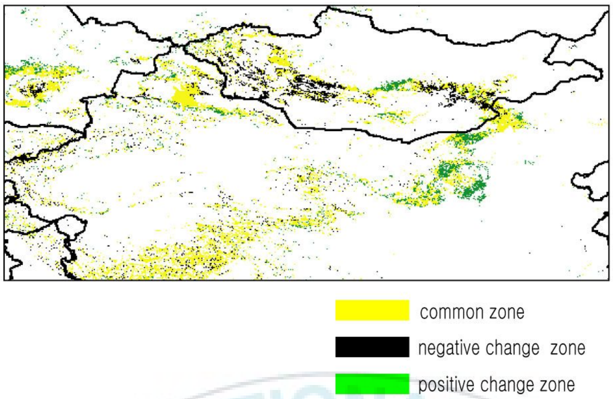


Fig. 12. Forward change in barren land

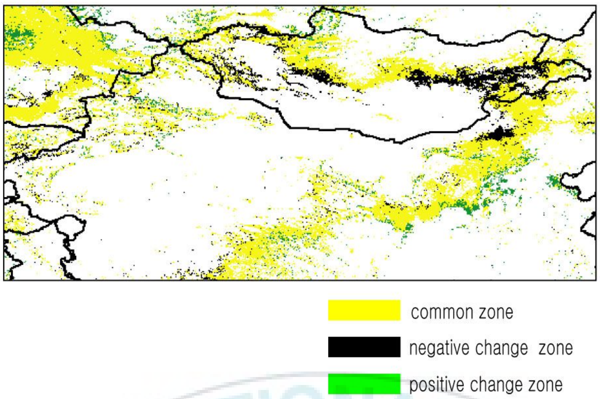
(a)



(b)

Fig. 13. Forward change in shrubland

(a)



(b)

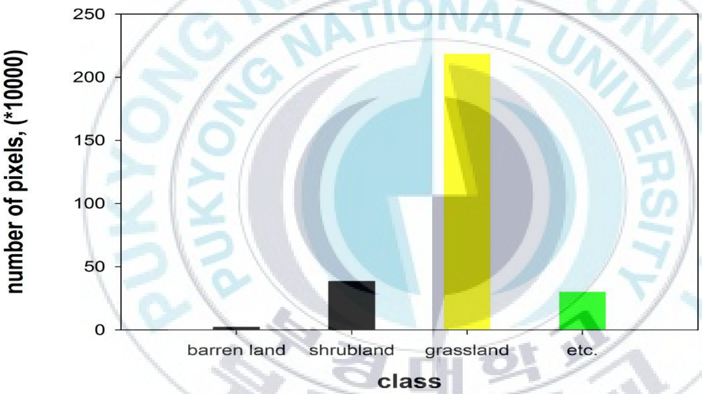
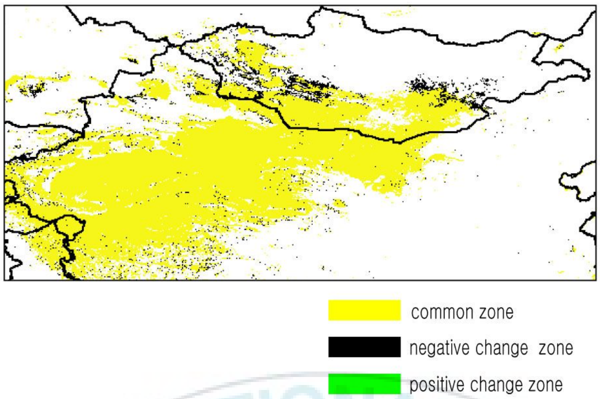


Fig. 14. Forward change in grassland

(a)



(b)

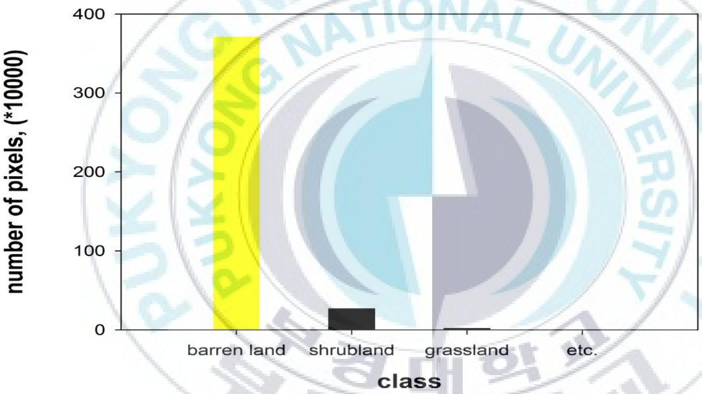


Fig. 15. Backward change in barren land

(a)

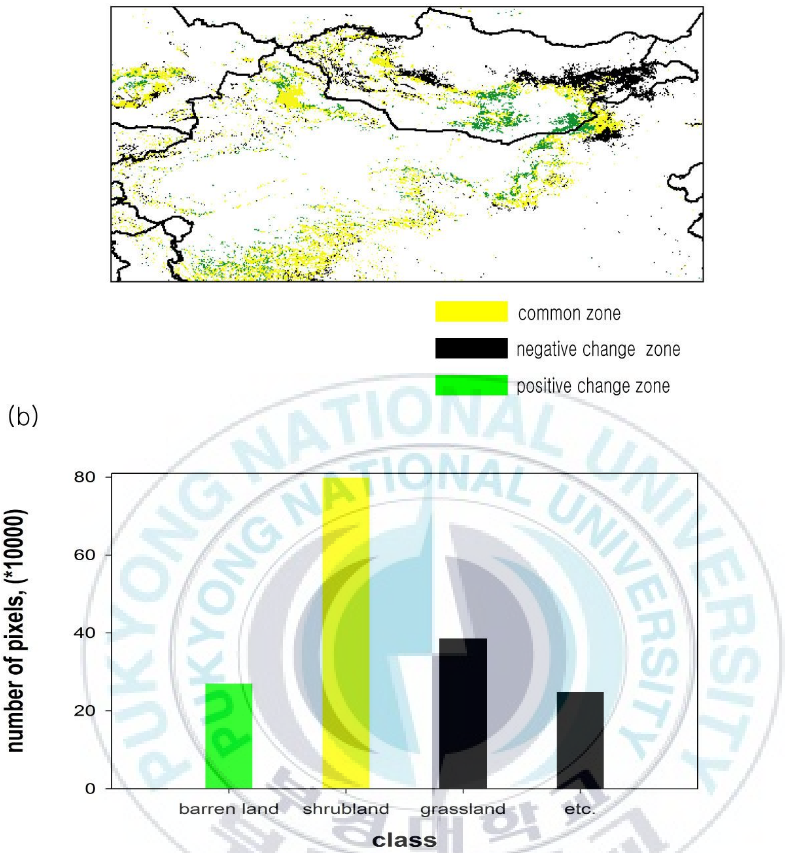
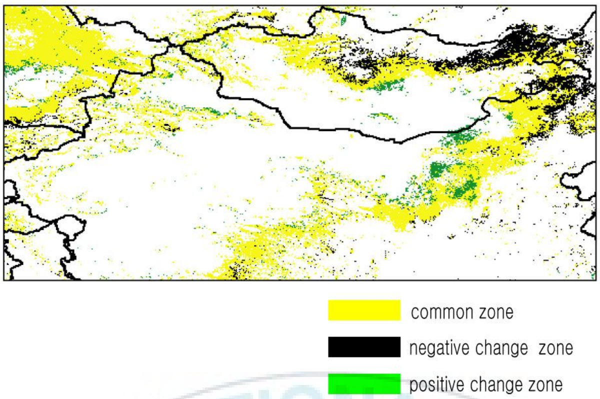


Fig. 16. Backward change in shrubland

(a)



(b)

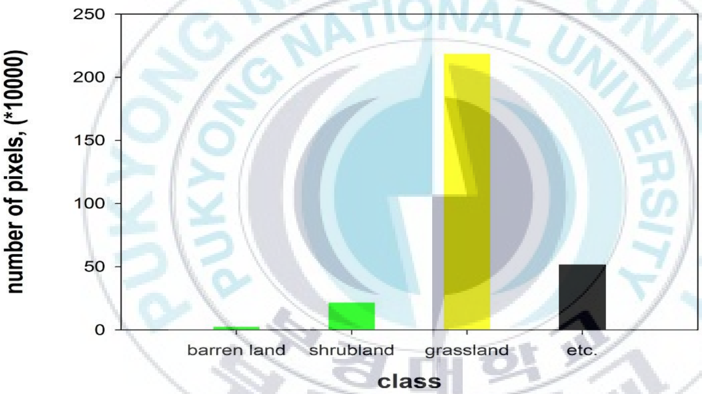


Fig. 17. Backward change in grassland

4. Conclusions

This study monitored the ecosystem surrounding the Gobi desert in North Asia using SPOT/VGT data with 1km resolution and analyzed quantitatively as well as qualitatively from 1999 to recent 2007. A monitoring vegetation was performed more closely to find out positive change as well as negative change. The vegetation cover has dramatically changed during the period 1999-2007 and there are significant extension of barren land between 1992 and 1999. However, some positive recoveries were catched in barren land after 2005. It seems to relate to social efforts of human and climate factor.

Among the five terms (1999-2003, 2003-2005, 2005-2007, 1999-2005, 1999-2007), there are many changes in 1999-2003 for barren land and in 2005-2007 for shrubland and grassland. A remarkable things in shrubland for 1999/2003 is that percentage of positive change (25%) is higher than percentage of negative change (13.3%), whereas percentage of positive change is lower than percentage of negative change for all classes and analysis terms except for shrubland during 1999/2003. Also, forward change and backward change analysis were considered in this study between 1999 and 2007. Quantities of the positive change pixels in forward change analysis for barren land is similar to the number of negative change pixels in backward change analysis.

For shrubland and grassland, negative change area is bigger than positive change area in both forward change analysis and backward change analysis

It is also apparent that precipitation factor has influence on the vegetation change like previous researches. Precipitation patterns are nearly similar to our classification results.

According to the numbers of study, the vegetation of North-east Asia has undergone considerable decrease over the last 30 years. It is apparent that climatic factors and humans activities have affected its vegetation condition. Therefore, monitoring the change of ecosystems is important for our global vegetation protection and we have to keep a careful watch on the problems related to ecosystems in this area constantly.

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