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ANALYSIS OF LAND DEGRADATION AND VEGETATION IN THE ZHEZKAZGAN COPPER ORE REGION ACCORDING TO THE SATELLITE IMAGES LANDSAT

This article encompasses the vital role of Remote Sensing and Geographic Information System in assessing the change of vegetation cover in Dzhezkazgan, Central Kazakhstan. The study site is well-known for copper mining operations which serves as one of the major source of livelihood among residents situated in the area. However, this manifestation implies with land degradation which is detrimental to vegetation. This research aims to assess quantitatively the ability of Normalized Difference Vegetation Index (NDVI) to extract meaningful vegetation abundance information by acquiring satellite images (i.e. Landsat Thematic Mapper ™, Enhanced Thematic Mapper Plus (ETM+), and Operational Land Imager (OLI)). The NDVI for land cover changes in a copper mining area were analyzed for the five different years – 1976, 1986, 1996, 2006 and 2015. The LANDSAT MSS imagery for 1976 and Landsat Surface Reflectance imagery for the years 1986 and 2015 were used for the study. NDVI differencing is used to come up with land/vegetation cover change detection analysis. The results showed a significant decrease in vegetation due to an increase in the area of mining areas. This study will greatly assist the local executive body, as well as mining organizations, in taking appropriate measures to ensure sustainable development of the region and the environment.

Key words: Vegetation cover change, time series analysis, NDVI, Landsat, copper mining area.

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«Жезқазған» мыс кен орнындағы жердің және өсімдік жамылғысы дегредациясын LANDSAT ғарыштық суреттері бойынша талдау

Бұл мақала Жезқазған, Орталық Қазақстанның жер бедері мен өсімдік жамылғысының өзгеруін бағалауда қашықтықтан зондтау мен географиялық ақпараттық жүйенің (ГАЖ) маңызды рөлін қамтиды. Зерттеу аймағы мыс кен орындарының жұмысымен жақсы танылған және бұл аймақтағы тұрғындардың өмір сүруінің негізгі көзі болып табылады. Дегенмен, бұл көрініс өсімдіктерге зиян келтіретін жердің деградациясын білдіреді. Зерттеу мақсаты жердің спутниктік бейнелерін алу арқылы өсімдіктер санының маңыздылығы туралы ақпаратты (мысалы, Landsat Thematic Mapper ™, Enhanced Tematic Mapper Plus (ETM +) және Operational Land Imager (OLI)) алу үшін Нормалданған Айырмашылық Өсімдіктер Индексінің (NDVI) қабілетін анықтауға бағытталған. Мыс өндіру аймағындағы жер қабатының өзгеруіне арналған NDVI бес түрлі кезеңде – 1976, 1986, 1996, 2006 және 2015 жылдарға зерттелінді. Зерттеуге 1976 жылы LANDSAT MSS үлгілері және 1986 және 2015 жылдарға арналған Landsat Surface Reflectance суреттері пайдаланылды. NDVI-дегі айырмашылықтар ландшафтық / өсімдік жамылғысының өзгерістерін анықтауға талдау жасау үшін қолданылады. Нәтижелер тау-кен учаскелерінің ауданын ұлғайту есебінен өсімдіктердің айтарлықтай төмендеуін көрсетті. Бұл зерттеу жергілікті атқарушы органға, сондай-ақ тау-кен өнеркәсібі ұйымдарына өңірдің және қоршаған ортаны тұрақты дамытуды қамтамасыз ету үшін тиісті шараларды қабылдауда үлкен көмек көрсетеді.

Түйін сөздер: өсімдік жамылғысының өзгеруі, уақытты сериялы талдау, NDVI, Landsat, мыс кен орны.

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Анализ деградации земель и растительности в Жезказганском меднорудном районе по данным космических снимков LANDSAT

Статья охватывает жизненно важную роль системы дистанционного зондирования и географической информации в оценке изменения растительного покрова в Жезказгане, Центральном Казахстане. Участок исследования хорошо известен для операций по добыче меди, который служит одним из основных источников средств к существованию среди жителей, расположенных в этом районе. Это исследование нацелено на количественную оценку способности Нормализованного Разностного Индекса Растительности (NDVI) извлекать значимую информацию о численности растительности путем приобретения спутниковых изображений (т. е. Landsat Thematic Mapper ™, Enhanced Thematic Mapper Plus (ETM +) и Operational Land Imager (OLI)). NDVI для изменения земельного покрова в районе добычи меди был проанализирован в течение пяти разных лет – 1976, 1986, 1996, 2006 и 2015 гг. Образцы LANDSAT MSS для 1976 года и изображения Landsat Surface Reflectance за 1986 и 2015 годы были использованы для анализа динамики свойств растительного покрова. Различия в NDVI используются для определения анализа обнаружения изменений ландшафта / растительного покрова. Результаты показали значительное уменьшение растительности за счет увеличения площади горнодобывающих районов. Данное исследование окажет большую помощь местному исполнительному органу, а также горным организациям для принятия надлежащих мероприятий в целях обеспечения устойчивого развития региона и окружающей среды.

Ключевые слова: изменение растительного покрова, анализ временных рядов, NDVI, Landsat, область добычи меди.

Introduction

Study area

Copper production has a leading position in the non-ferrous metallurgy in Kazakhstan. Its proven reserves are estimated at 6% of the World or 37 million tons. According to this index the Kazakhstan occupies the 4th - position after Chile, Indonesia and the United States. On the territory of the Republic of Kazakhstan more than 90 explored deposits of copper. The main volumes of balance reserves are concentrated in the Central Kazakhstan (Dzhezkazgan). Dzhezkazgan deposit is located in the southwestern part of Central Kazakhstan (Figure 1) and consists of an open pit mine (North), six underground mines (Jomart, Stepnoy, Annensky, and East, South and West), two copper concentrators and one small zinc-lead concentrator, a smelter, a refinery and a wire rod plant.

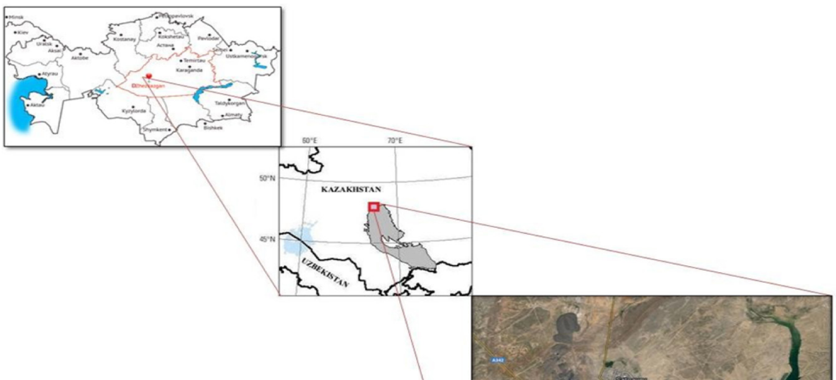


Figure 1 – Location of Dzhezkazgan copper mining area, Central Kazakhstan

Operation of mining companies in Dzhezkazgan copper mining causes intensive groundwater depletion under the influence of the powerful mine drainage effect. This, in turn, affects depletion of vegetation species composition, deterioration of soil cover, leads to increased wind and water erosion. Changes in environment components are directly manifested by direct deterioration of terrain and activation of natural and anthropogenic processes, including development of gravitational and erosional processes on slopes of quarries and various dumps. Furthermore, indirect impact is also observed of mining on the nature and intensity of the terrain-forming processes through changes in structural components of geosystems (through air pollution, pollution and increasing aggressiveness of surface, ground and underground water, changing soil structure and transformation of the species composition of vegetation). Since the territory of Dzhezkazgan located in the area of surface water deficit, the drinking and household needs are satisfied primarily by groundwater. As a result, begin to dominate the fast descent of significant parts of the upper part of the lithosphere due to the gravitational compression fracture systems and then in terrestrial masses (Baymyrzayev, 2000). These phenomena are frequent in Dzhezkazgan copper mining area (see Figure 2). They are especially dangerous for the communities located near or above the underground mining workings.

To understand the causal effect of disturbance on flora, a time series on land cover change is needed.

Figure 2 – Anthropogenically disturbance of terrestrial surface in the native fields of Dzhezkazgan copper mining area

Recent studies have shown that biodiversity of terrestrial ecosystem is expected to be mainly affected by land use changes within the next 100 years (Sala et al., 2000).The change in land cover as a result of anthropogenic activities has played a major role in global environmental change and hence has become a hot spot for researchers (Liu et al., 2002). It is the process of identifying variations in an object or phenomenon by observing it at different times (Singh, 1989). The detailed process involves superimposing maps of more than one time period over each other to find the change (Jessica et al., 2001). Remote sensing technology in tandem with a variety of GIS applications can be an effective tool for monitoring mine activities (Lamb, 2000). The Normalized Difference Vegetation Index (NDVI) was developed in the late 1960s and has proven to be a useful indicator for measuring photosynthetic activity in vegetation (Vicente et al, 2004). The NDVI is one of the most important and commonly used vegetation indexes, defined as equation NDVI = (NIR – RED) / (NIR + RED), where RED is the reflectance in the red channel and NIR is the reflectance in the near-infrared channel. The RED and NIR band contains more than 90% of vegetation information (Baret et al, 1989).

Materials and methodology of researches

The process of utilizing Landsat data for to investigate the environment and land cover change of Dzhezkazgan copper mining area followed a multi-phase approach. Prior to beginning the analysis, satellite images and GIS data pertaining to the study area were obtained, and preprocessing operations were completed. The first phase of analysis consisted of identifying areas of change using the supervised classification. The second phase included the calculation of NDVI and creating different images to identify areas of decreasing. The methodologies adopted in the research to reach the results are as shown in the Figure 3. These phases are explained more thoroughly in the following sections.

Data acquisition and source

Prior to analysis, it was necessary to locate suitable satellite imagery and other GIS data for the study area. Five Landsat scenes were selected and downloaded from the USGS Landsat archive. The images acquired were captured in June, July, and August of 1976, 1986, 1996, 2006 and 2015 years (Table 1, Figure 4). Images from summer period were chosen so that the area could be studied while vegetation growth was at its peak, maximizing differences between vegetated and non-vegetated areas. The images selected were free of cloud cover across the study area.

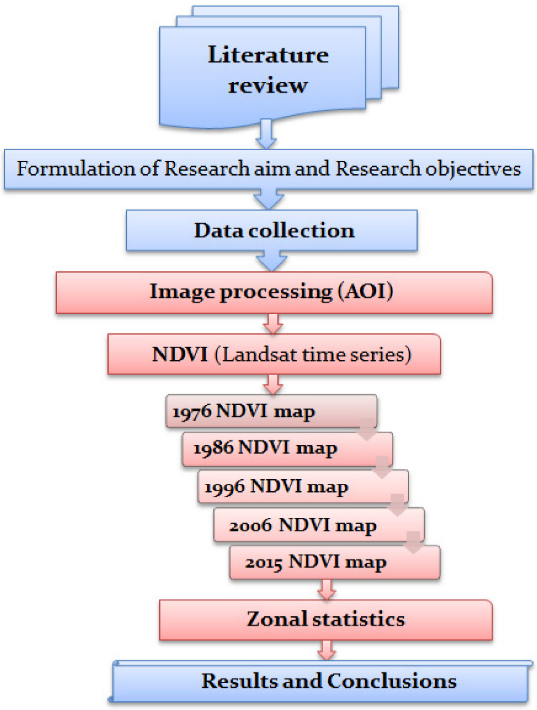


Figure 3 – Flowchart of the Research process

Table 1 – Acquired Landsat data characteristics

№	Date acquired	Landsat Scene Identifier	Sensor type	Resolution (m)
1	05.06.1976	LM21690271976157	Landsat 2 MSS	79
2	31.05.1986	LT51570271986152	Landsat 5 TM	30
3	30.07.1996	LT51570271996212	Landsat 5 TM	30
4	20.08.2006	LT51560272006232	Landsat 5 TM	30
5	04.08.2015	LC81570272015216	Landsat 8 OLI	30

Pre-processing

Because the spatial extent of the two Landsat images is far greater than the study area and the aerial photography available for geometric registration, the images were first subset to a smaller area using a bounding rectangle around the study area. Layer Stacking is a method used to combine multiple layers of data into a single dataset. This method builds a multi-band file from georeferenced images of similar pixel sizes, and projections, where each band represents a time slice. The Layer Stacked data were subset to include only the study region to decrease file size and increase processing efficiency in later analysis (Figure 5).

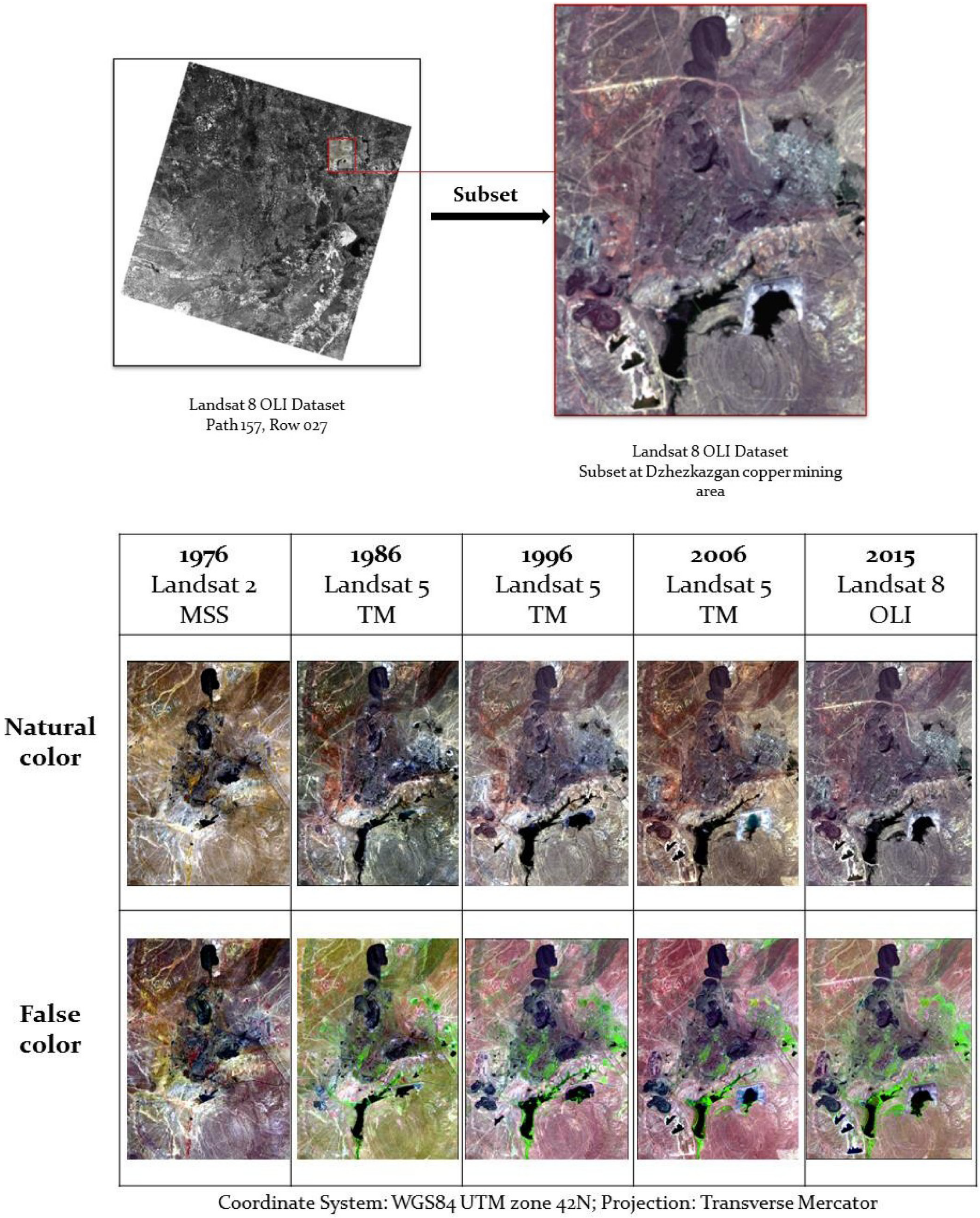


Figure 4 – Composite images of Dzhezkazgan copper mining area in 1976, 1986, 1996, 2006, and 2015

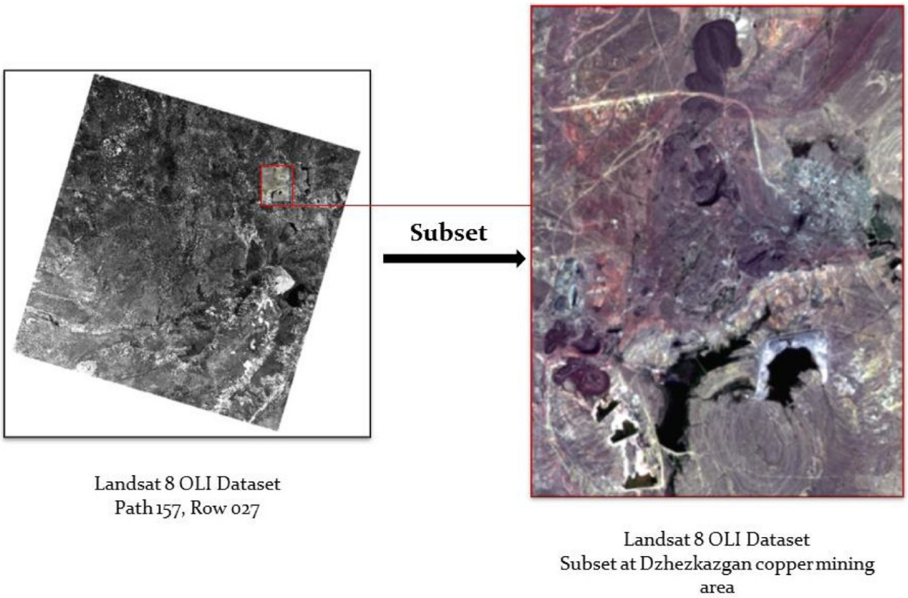


Figure 5 – Subsetting Landsat 8 OLI data product; example from August, 2015Dataset

All data products were processed using ERDAS IMAGINE, ArcGIS, QGIS, a geospatial imagery analysis software. Data extraction tools for this study include Normalized Difference Vegetation Index (NDVI) transformation.

Georeferencing the images

Data were obtained using the United States Geological Survey (USGS) Global Visualization Viewer (http://earthexplorer.usgs.gov/). All of the images acquired had already been georeferenced by the USGS, with a Standard Terrain Correction that provides better geometric accuracy. The collected data were projected on a Universal Transverse Mercator (UTM) geographic coordinate system, using the World Geodetic System (WGS) from 1984, zone 42N.

The software applies radiometric calibration and atmospheric correction algorithms to Level-1 Landsat data products. What this means for users of Landsat data, is that you can access data that has been pre-processed to top-of-atmosphere (TOA) reflectance, surface reflectance, or (in the case of thermal bands) brightness temperature. The data products also include masks for clouds, cloud shadows, adjacent clouds, land, and water. Users can also order several spectral index products for their Landsat scenes.

Limitations

The Landsat Multispectral Scanner (MSS) imagery of the 1976 year with four spectral bands has a poor spatial resolution of 79 meters in comparison to the Landsat TM and Landsat OLI images of the years 1986, 1996, 2006, 2015 which have a spatial resolution 30 meters. Landsat Thematic Mapper (TM) images consist of seven spectral bands with a spatial resolution of 30 meters for Bands 1 to 5 and 7. Spatial resolution for Band 6 (thermal infrared) is 120 meters, but is resampled to 30 meter pixels. Landsat 8 Operational Land Imager (OLI) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. Hence the accuracy of Landsat MSS image of the 1976 year is low in comparison to the other years.

Change Detection Methodologies

The objective of this methodology is to detect all changes of land cover for multi-temporal images using different filtering scenarios utilizing ERDAS environment. For detecting, assessing, and mapping the land cover changes of the study area during the period from 1976 to 2015, the Landsat imagery dataset was used. Change detection involves the use of multi-temporal image data sets to discriminate the changes between the dates of imaging. There are many techniques adopted in this research, in order to monitor the progress of vegetated regions and each type of changes was quantified to zonal statistics using ArcGIS techniques.

NDVI calculation and ndvi maps

NDVI or Normalized Differential Vegetation Index was calculated for all the five images and subsequent NDVI maps were created with NDVI values ranging from -1 to +1. The NDVI calculations for five different sensors are as shown in Table 2.

The Normalized Difference Vegetation Index is calculated as the difference between the red and infrared bands divided by the sum of the red and infrared bands. Landsat data, this is simply: Band 3 (Red) – Band 4 (IR) / Band 3 (Red) + Band 4 (IR). The NDVI images for five different sensors are as shown in Figure 6. Generally, healthy vegetation will absorb most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum.

Table 2 – NDVI Calculation

Years	Image type	NDVI Function	NDVI Range
1976	Landsat 2 MSS	(Band3-Band2) / (Band3+Band2)	-0.022-0.110
1986	Landsat 5 TM	(Band4-Band3) / (Band4+Band3)	0.070-0.349
1996	Landsat 5 TM	(Band4-Band3) / (Band4+Band3)	0.029-0.443
2006	Landsat 5 TM	(Band4-Band3) / (Band4+Band3)	0.062-0.401
2015	Landsat 8 OLI	(Band5-Band4) / (Band5+Band4)	0.041-0.507

The Normalized Difference Vegetation Index is calculated as the difference between the red and infrared bands divided by the sum of the red and infrared bands. Landsat data, this is simply: Band 3 (Red) – Band 4 (IR) / Band 3 (Red) + Band 4 (IR). The NDVI images for five different sensors are as shown in Figure 6. Generally, healthy vegetation will absorb most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum.

Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves. Very low values of NDVI (0.1 and below) correspond to barren areas of rock, sand or snow. Moderate values represent shrub and grassland (0.2 to 0.3), while high values indicate temperate and tropical rainforests (0.6 to 0.8).

Results and discussion

This study was based on copper mining area in Central Kazakhstan. This region provides nearly half of the copper mined in the Kazakhstan and will likely see an increase in mining over the next 40 years. The government agencies responsible for monitoring mining and reclamation in the region are stressed by increased workloads from copper mining and other mineral extraction activities. Utilizing Landsat satellite images through the U.S.G.S. archive makes it possible to monitor surface mining and environment, and to characterize land cover changes as a result of mining.

The purpose of this study was to investigate and evaluate how remote sensing techniques can be utilized as a tool for land cover change and environment of copper mining area. In addition, this study sought to characterize the effects of increased copper production on the area.

Five Landsat images were acquired from three anniversary dates for analysis. These images were analyzed to detect disturbance caused by mining, identify reclamation sites, and to detect land cover change over the 40 years horizon. Indicators were employed that could be measured over time to monitor disturbance from surface mining. Investigation the disturbance of ground surface can help assess the risk of adverse environmental effects from mining. The results indicate that remote sensing is a useful tool for monitoring disturbance from surface mining activities, and for assessing the relative vegetative health of reclamation sites, as well as land cover changes.

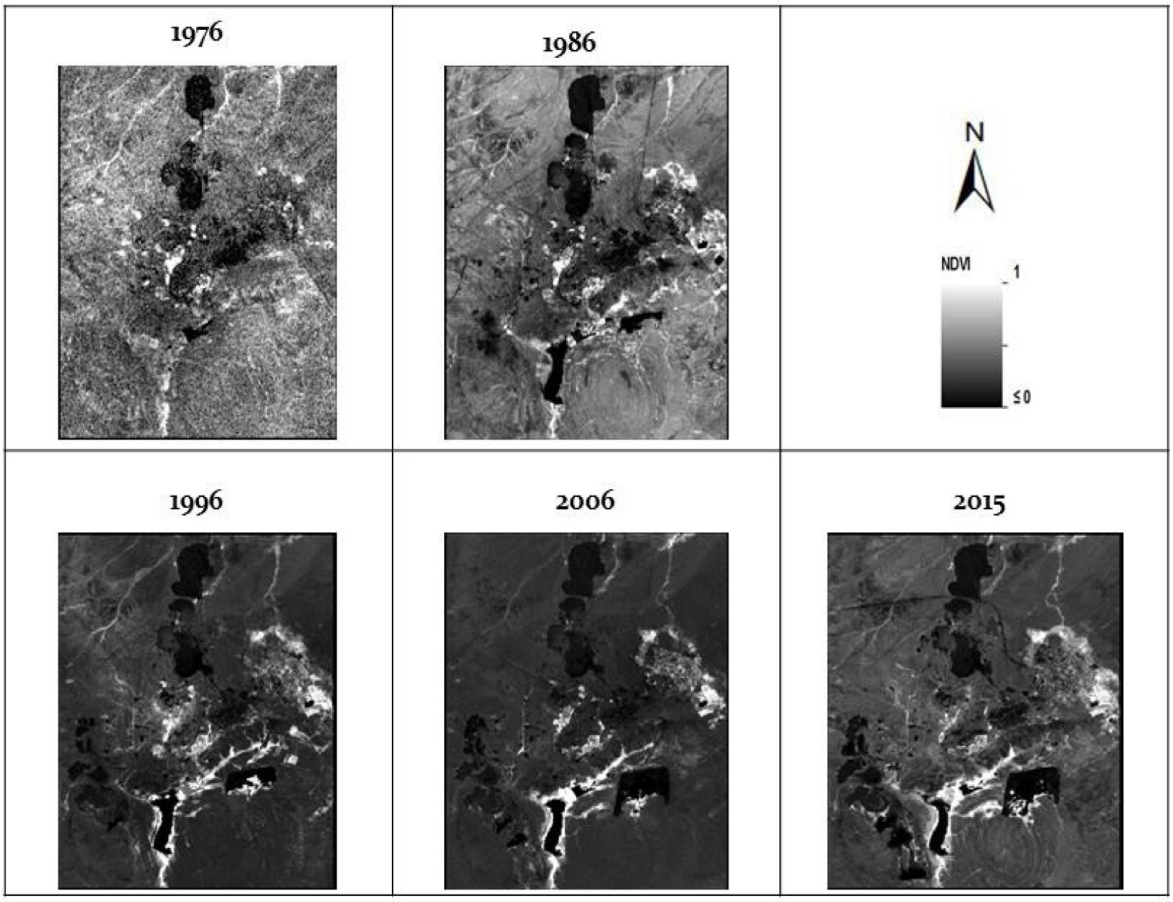


Figure 6 – NDVI variation computed using Landsat image for five different years

NDVI Analysis

The NDVI maps of the study area produced clear and complete footprints of each mine within the area (Figures 7 to 11). Active mine areas were strongly associated with low NDVI values compared to the rest of the landscape. Mining areas are clearly in evidence in the NDVI images in Figures 26-30. In this figure, low NDVI values correspond to the lighter tone and indicate areas were vegetation has been disturbed or removed. A comparison of the dates illustrates the intensification in mining activities between 1976 and 2015, and a shift in mining locations as they slowly progressed.

Areas with the highest NDVI values include reclaimed, or revegetated areas, and riparian zones near the tailings, settlements and streams in the study area.

The southern, northern portion of the NDVI images from 1976 and 1986 in Figures 26, 27 contains much higher NDVI values than the 1996 or 2006, 2015 images. This is presumably due to differences in the precipitation patterns between the five years. The summers of 1996, 2006 and 2015 seems to have been much drier than 1976 and 1986. Difference images generated by subtracting the NDVI image from one year with that of another year were very useful for this task. New mining areas occur to the north and west of existing mine sites. Reclaimed areas fall directly behind the new mining sites, as reclamation tends to follow mining activities closely. The trend of mining extending to the north and west is enhanced in this image, as many newly disturbed areas appear in areas near the mines, signified by decreases in NDVI value. This is further proven by the presence of areas in the southern and eastern portions of the mine areas that show increases in NDVI values, signifying revegetation or reclamation. These changes are very drastic as the image shows large tracts of land that have been disturbed. Large areas that were once undisturbed by the relatively small amount of mining that was occurring in the study area in 2015, are now dominated by extensive surface mines that are several miles long in some places. Given the great increase in copper production between dates, this would be expected. Conversely, areas where mines were located in 1996 are now greatly improved, as most of these areas were likely reclaimed during the 10-year period. A great amount of information can be drawn from NDVI analysis and change detection. Land cover mapping allows the analyst to confirm these findings and to assess the effects of increased mining on the landscape of the study area. Overall, the pattern reveals expanded disturbance in the study area and a trend of new mining occurring to the west and the north of existing mines.

Descriptive statistics were obtained to examine NDVI change by-pixel for each benchmark period in the AOI Table 4 provides a summary of statistics for the Reference AOI, while Figures 31-34 provide a graphical visualization and a quantitative representation of the interquartile range of NDVI, respectively.

Table 4 – Summary NDVI Statistics of AOI in 1976, 1986, 1996, 2006 and 2015

Years	NDVI min value	NDVI max value	NDVI mean value	NDVI StdD
1976	-0,313	0,503	0,037	0,037
1986	-0,464	0,775	0.179	0,085
1996	-0,67	0,828	0,153	0,126
2006	-0,654	0,811	0,156	0,112
2015	-1,147	0,88	0,202	0,155

The exact dates and corresponding summary statistics of the NDVI min, max, mean, StdD averages of AOI during the growing season from 1976 to 2015 can be found in Table 4, Figures 12-15.

Analysis suggests that surface mining in AOI was responsible for the decrease of vegetation productivity from 1976 to 2015. The maximum NDVI during the growing season ranged from 0,503 in 1976 to 0,88 in 2015. The exact dates and corresponding summary statistics of the maximum mean NDVI of the AOI during the growing season from 1976 to 2015 can be found in Table 3. The exact dates and corresponding summary statistics of the NDVI min, mean, StdD averages of AOI during the growing season from 1976 to 2015 can be found in Table 4.

Land cover change Analysis

Remote sensing and GIS are important tools for studying land use patterns and their dynamics (Prakash and Gupta, 1998). Change detection using satellite data can allow for timely and consistent estimates of changes in land use and land cover over large areas. The nature of the changes being investigated can vary considerably, from relatively short term events such as snow cover, flooding and forest fires, to longer trends like suburban development, deforestation, glacial retreat or wetland loss (Shank, 2009). NDVI vegetation change maps of Dzhezkazgan copper mining area for all the five years were created using the above supervised classification scheme by using the following steps:

Demarcation of all the areas belonging to each class.

Allocating suitable colors to each class.

Calculating areas of class.

1976, 1986, 1996, 2006 and 2015 in study areas land cover change statistics were calculated using ArcGIS software (Figure 16).

Land cover classification produced very clear results for copper mining area. The results of land cover mapping illustrate increased surface disturbance across the study area caused by increased mining from 1976 to 2015. Direct comparison of land cover maps produced from two different image dates was useful for visually assessing change, however determining exactly where that change occurred and exactly which land cover types had been converted proved to be more difficult.

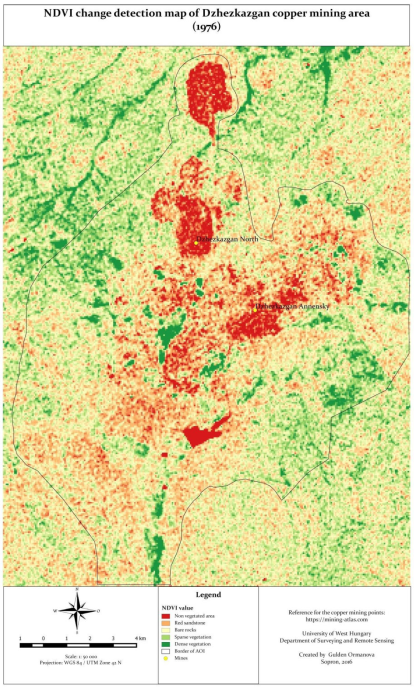


Figure 7 – NDVI change detection map of copper mining area (1976)

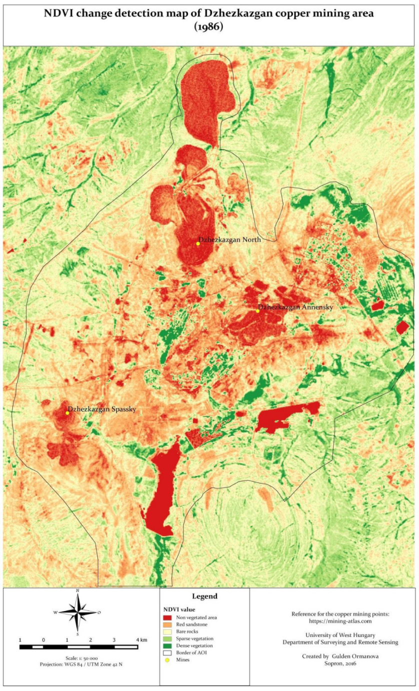


Figure 8 – NDVI change detection map of copper mining area (1986)

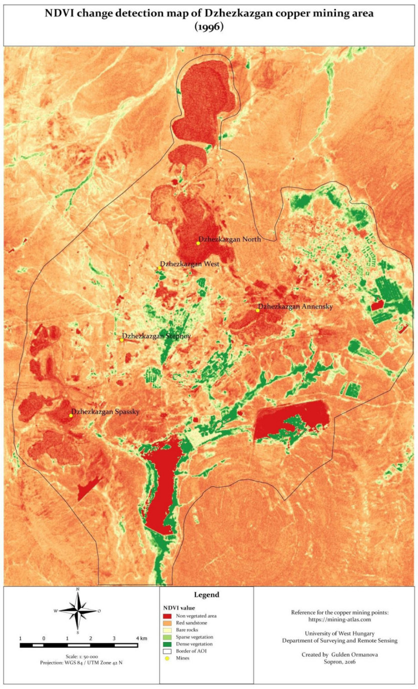


Figure 9 – NDVI change detection map of copper mining area (1996)

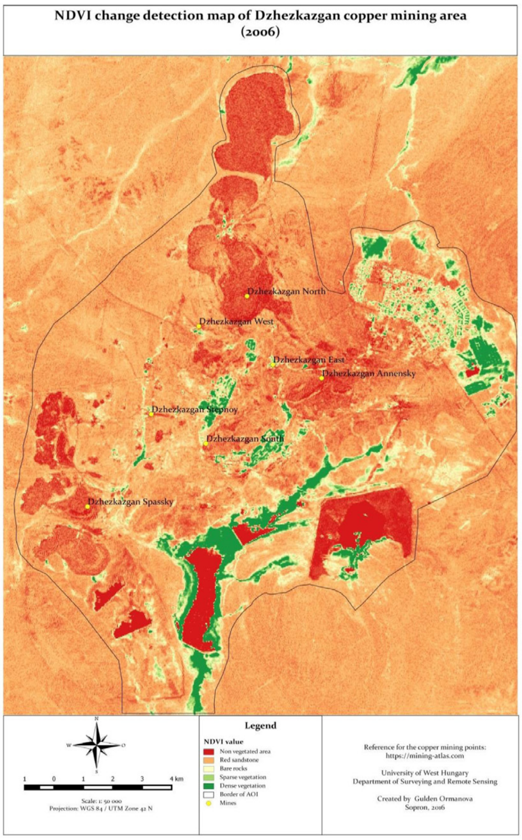


Figure 10 – NDVI change detection map of copper mining area (2006)

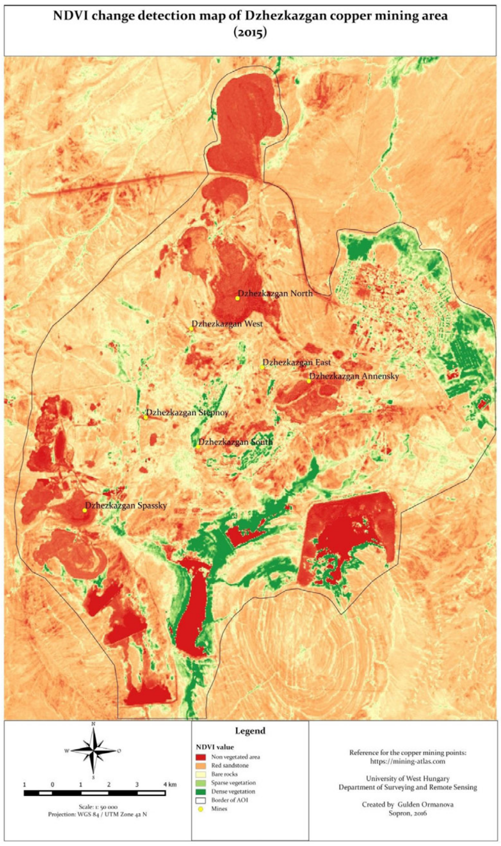


Figure 11 – NDVI change detection map of copper mining area (2015)

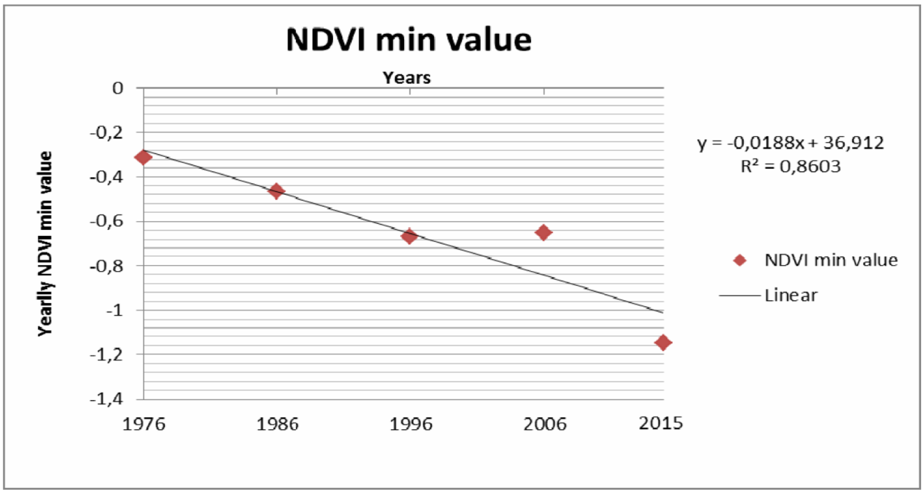


Figure 12 – NDVI min value of AOI using in 1976, 1986, 1996, 2006 and 2015

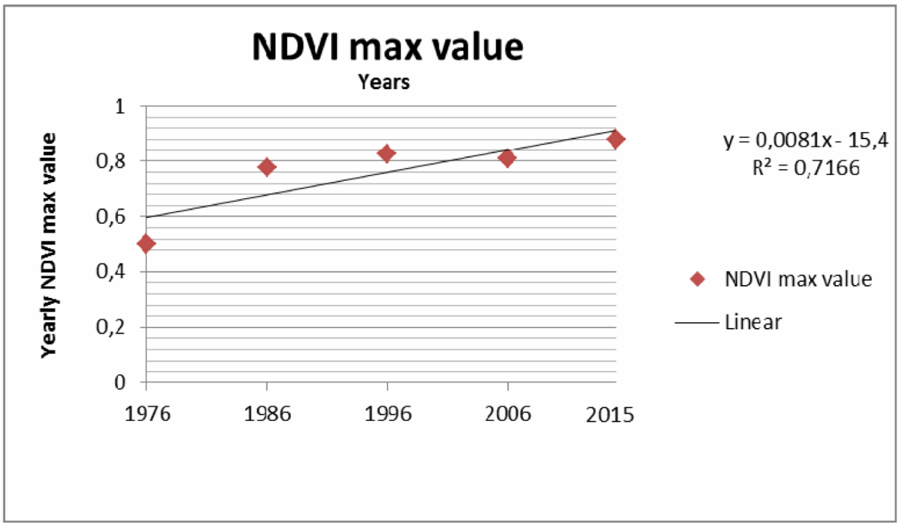


Figure 13 – NDVI max value of AOI using in 1976, 1986, 1996, 2006 and 2015

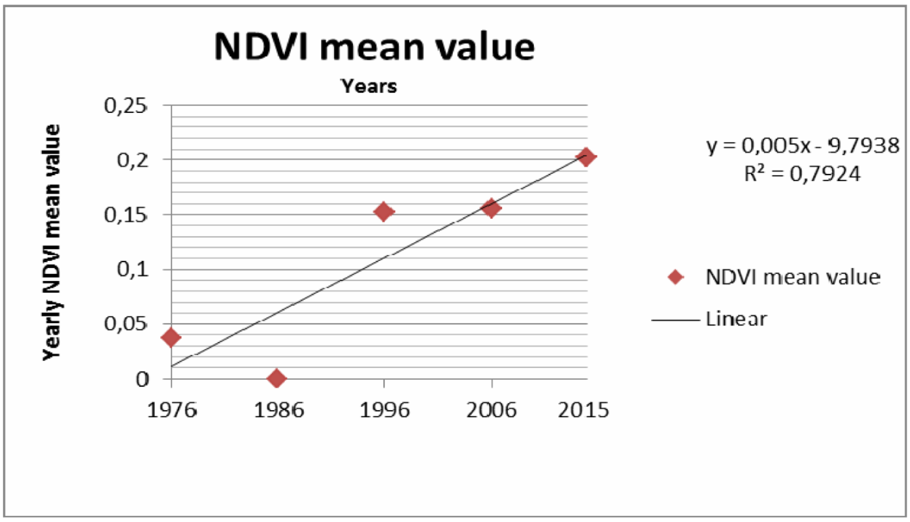


Figure 14 – NDVI mean value of AOI using in 1976, 1986, 1996, 2006 and 2015

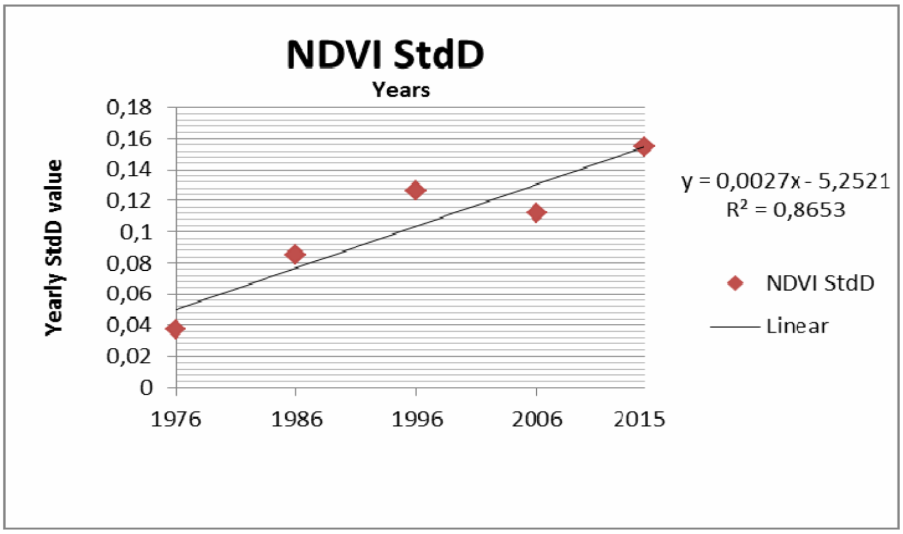
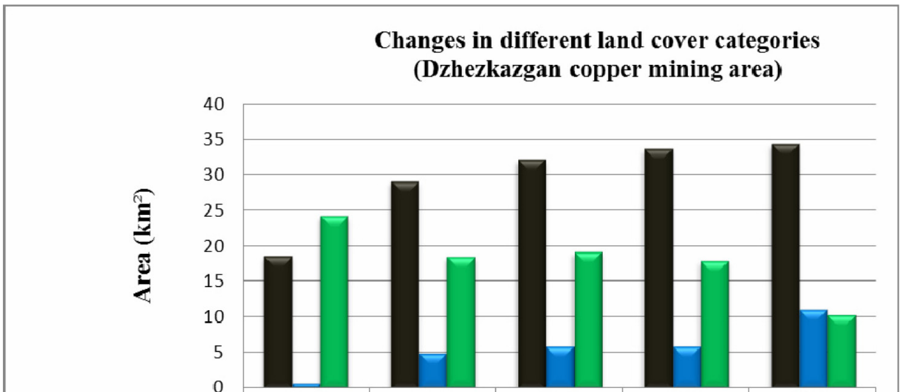


Figure 15 – NDVI StdD of AOI using in 1976, 1986, 1996, 2006 and 2015



	1976	1986	1996	2006	2015
open pit mining area	18,5688	29,1483	32,1255	33,7455	34,4304
grounwater/tailings	0,6876	4,8384	5,8716	5,9089	10,9737
vegetation	24,1956	18,4023	19,1212	17,8938	10,3113

Figure 16 – Changes in different land cover categories

Conclusions

The Dzhezkazgan is a major source of the copper consumed in the Kazakhstan, and copper production is expected to increase during the next 40 years. The result of the work signified that there was a rapid change of land/vegetation cover during the period from 1976 to 2015. Therefore, it concludes that increase of mining activities will cause damage to vegetation. NDVI is indispensable in determining vegetation abundance information because it accounts for variations in shadow due to sun elevation angle and is least influenced by topography. The analysis of multiple time-series satellite images may allow a non-stop monitoring of mining activity over the areas under scrutiny. Furthermore, it has a potential of predicting future trends in land/vegetation cover dynamics over the studied regions.

Landsat images were acquired from 1976, 1986, 1996, 2006 and 2015 for analysis. The Normalized Difference Vegetation Index was used to map active mining and reclamation areas, and NDVI difference images were created to assess the growth of mining operations over the 10-year time span. Results from this study suggest that vegetation reclamation has not restored surface-mined lands to equal or greater productivity to the natural vegetation cover on Dzhezkazgan copper mining area in Central Kazakhstan. Because surface mining in Dzhezkazgan is wide-spread, the lack of proper vegetation reclamation can have vast impacts on ecosystem function.

The approach used in this study provides a low-priced image processing analysis. It is reliable for assessing land cover change, landscape structure etc. or a research type project whenever the spatial data, attribute data and materials used are available.

References

Baret, F., Guyot, G. and Major, D.J. (1989): TSAVI: A vegetation index which minimizes soil brightness effects on LAI and APAR estimation. Proceedings of the 12th Canadian Symposium on Remote Sensing. Vancouver ,Canada, pp. 1355- 1358.

Baymyrzayev K.M., (2000): Natural and resource potential in Central Kazakhstan and problems of its rational development, Almaty, Kazakh University, pp. 268.

Jessica, P.K., M.C. Porwal, P.S. Roy and G. Sandhya: Forest change detection in Kalarani Round, Vadodara, Gujarat, (2001): A Remote Sensing and GIS approach. J. Ind. Soc. Rem. Sensing, 29, pp. 129-135.

Lamb, A. D., (2000): Earth observation technology applied to mining-related environmental issues, Mining Technology, 109: pp. 153-156.

Liu J, Liu M and Zhuang D.J, (2002): A study on spatial pattern of land-use change in China in recent years. Science in China, Ser.D, 32(12), pp.1031-1040.

Prakash, A., Gupta, R.P., (1998): Land-use mapping and change detection in a coal mining area: a case study in the Jharia Coalfield, India. International Journal of Townsend Remote Sensing 19, pp. 391–410.

Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L. F., Jackson, R. B., Kinzig, A., Leemans, R., Lodge, D. M., Mooney, H. A., Oesterheld, M., Poff, N. L., Sykes, M. T., Walker, B. H., Walker, M., and Wall, D. H., (2000): Global Biodiversity Scenarios for the Year 2100. Science 287: pp. 1770-1774.

Shank, M., (2009): Mapping vegetation change on a reclaimed surface mine using QuickBird. In: R. Barnhisel (Editor), National Meeting of the American Society of Mining and Reclamation, Revitalizing the Environment: Proven Solutions and Innovative Approaches. ASMR, Billings, MT, USA.

Singh A, (1989): Digital change detection techniques using remotely-sensed data, International Journal of Remote Sensing, 10, pp. 989-1003.

Vicente-Serrano, S. M., Lasanta, T., Romo, A., (2004): Analysis of Spatial and Temporal Evolution of Vegetation Cover in the Spanish Central Pyrenees: Role of Human Management Environmental Management, 34, pp. 802-818.