



Change Detection and Estimation of Illegal Mining using Satellite Images

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ABSTRACT

Viewing the Earth from space is now crucial to the understanding of the usage of man's activities on his day to day resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental changes like illegal surface mining.

The purpose of this paper is to evaluate how digital image processing and remote sensing techniques can be utilized as a tool for monitoring surface illegal mining operations and can be integrated into the monitoring process, allowing the regulatory agencies responsible for monitoring surface illegal mining and reclamation to do so more efficiently and help avoid or minimize the adverse effects of illegal mining. Data includes satellite images and GIS layers from the study area. These techniques will be useful for monitoring the progression of disturbance caused by illegal mining, identifying and tracking reclamation sites, and assessing land cover changes. Monitoring the illegal mining and reclamation of these lands is critical to ensure and they will be returned to their natural state. Many of the government agencies charged with monitoring illegal mining activities are already stressed by ever-growing workloads, as well as budgetary concerns.

Key words: Change Detection, Surface Mining, Remote Sensing & GIS, Image Processing.

1 BACKGROUND TO THE STUDY

Various studies have shown that there remain only few landscapes on the Earth that is still in their natural state. Due to anthropogenic activities, the Earth surface is being significantly

altered in some manner and human being's presence on the Earth and their use of land has had a profound effect upon the natural environment thus resulting into an observable pattern in the landuse/land cover over time.

The land use/land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes.

Remote Sensing (RS) with Image processing techniques and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biologicaldiversity (Wilkie and Finn, 1996).

2 LITERATURE REVIEW

George P. Petropoulos, Panagiotis Partsinevelos and Zinovia Mitraka (2012) carried out a study on multi-temporal change detection scheme based on Landsat TM imagery and SVMs was proposed for identifying, quantifying and

analysing the spatio-temporal response of the landscape due to mining activities. The potential of the technique was explored using as a case study two mining sites located in the intensive mining exploration area of Milos Island in Greece. The mining activity interpretation model implemented proved successful in monitoring the level of surface mining and reclamation in both study regions for a period of 23 years (1987–2010). Areas affected by the mining activity and also reclaimed areas and reclamation trends were clearly identified. However, to quantify the rate of the changes that occurred in a monitoring framework, the analysis of more TM images acquired at shorter time intervals is required.

They have been implemented this based on satellite imagery analysis provided nowadays globally at no cost. It is also easy to be applied and computationally inexpensive for small-scale studies, requiring much less effort in comparison for example to a visual image interpretation-based approach. From an algorithmic perspective, a further advantage of the method is its dependence to a small number of training points that is also resulting in highly robust and accurate results, even in highly fragmented and dynamically changing landscape environments such as the ones of their test sites.

Philip A. Townsend, David P. Helmers, Clayton C. Kingdon, Brenden E. McNeil, Kirsten

M. de Beurs, Keith N. Eshleman (2009) carried out a study on Accurate quantification of the extent of mining activities is important for assessing how this LCLUC affects ecosystem services such as aesthetics, biodiversity, and mitigation of flooding. They used Landsat imagery from 1976, 1987, 1999 and 2006 to map the extent of surface mines and mine reclamation for eight large watersheds in the Central Appalachian region of West Virginia, Maryland and Pennsylvania. Surface mining and reclamation is the dominant driver of land cover land use change (LCLUC) in the Central Appalachian Mountain region of the Eastern U.S. They employed standard image processing techniques in conjunction with a temporal decision tree and GIS maps of mine permits and wetlands to map active and reclaimed mines and track changes through time.

For the entire study area, active surface mine extent was highest in 1976, prior to

implementation of the Surface Mine Control and Reclamation Act in 1977, with 1.76% of the study area in active mines, declining to 0.44% in 2006. The most extensively mined watershed, Georges Creek in Maryland, was 5.45% active mines in 1976, declining to 1.83% in 2006. For the entire study area, the area of reclaimed mines increased from 1.35% to 4.99% from 1976 to 2006, and from 4.71% to 15.42% in Georges Creek.

Ololade, H.J. Annegarn, D. Limpitlaw and M.A. Kneen (2008) carried out a study on the analysis of land cover/use changes over three decades have revealed a highly dynamic interchange of land use, driven by competition for land between urbanisation, agriculture and mining.

3 CHANGE DETECTION

Two images, different time acquisition, area inspected is changed

Visually changes (spatially) –simple

Non visible changes (Spectrally) – difficult Mining area related types of changes

- Exposure of underground layers
- Material/ mineral pile transfer
- Detect new waste dumps
- Detect changes/ alteration in waste dump mineral composition
- Health of vegetation in Abounded and re-cultivated mines
- Soil degradation
- Water quality in lakes and rivers
- Extracted material transportation routes monitoring
- Manmade changes
- Includes changes such as new buildings, road, relocation of portable structures etc.
- Land use land cover changes

4 SURFACE MINING METHODS

Surface mining operations typically involve some sort of strip mining during the lifespan of a given mine. Strip mining, in general is characterized by the removal of overburden to expose the mineral for extraction. Surface mining is typically employed in situations where the overburden is relatively thin, or where underground mining would not be economically feasible. The main types of surface mining include: area mining, contour mining, mountaintop mining, and auger/highwall mining.

Area mining is typically conducted on flat or gently rolling terrain, and is used to extract coal over a large area. An area mine starts with an initial cut to expose the coal seam to be removed. The seam may then be removed, creating an open pit. Spoils and overburden are placed in a valley fill or some other disposal site. Materials that may be prone to leaching acid- or toxic-forming materials may be segregated from the rest of the overburden so that they may be isolated from exposure to oxygen and water. As the operation progresses, spoil from new cuts is used to backfill pits left from previous cuts (USEPA, 2005).

Contour mining takes place in mountainous or rolling hill areas where it is uneconomical or infeasible to remove all of the overburden from a particular coal seam, and mining is limited to the side of a mountain or to the end of a ridge line. Typically mining operations progress along the outcrop of a coal seam, removing overburden inward toward the mountaintop or ridge core until the highwall limit of that coal seam is reached. The highwall limit is determined by its stripping ratio. This results in mine cuts that wrap around mountaintops or ridge lines parallel to the contour of the land in a sinuous pattern dictated by topography (USEPA, 2005).

Mountaintop mining is an extreme version of area strip mining. In a mountaintop mining operation the overburden is removed to expose the coal seam. The rocky material is then deposited in hollows and valleys adjacent to the mine, creating a valley fill. After coal extraction is completed, the area is reclaimed as a flat space. This method of mining results in alterations of the topography and drainage of the area. Mountaintop mining is sometimes used to re-mine areas previously mined by underground techniques. In some cases, coal from several seams may be extracted to maximize the profitability of mining the area (USEPA, 2005).

Auger mining and highwall mining are predominately secondary extraction techniques, used after mining with one of the other methods of surface mining. When the stripping ratio becomes too high to justify further excavation, the final boundary formed by the mine is called the highwall. Rather than abandoning or covering the mine, and leaving valuable minerals behind, augers and continuous highwall miners are used to

recover a portion of the coal remaining in the highwall. A traditional auger uses open thread steel drill sections behind a cutting bit. The auger is positioned adjacent to the coal seam and breaks up the coal as it slowly rotates through the seam. As it does so, chunks of coal are drawn out through the open drill thread. Augers can penetrate a coal seam to a depth of approximately 130m (about 400ft), recovering between 30-40% of the coal (O'Hagan, 1997).

4.1 RECLAMATION PROCEDURES

Reclamation is the process of returning disturbed lands to their previous state or use, or to a comparable state. Reclamation is intended to stabilize the terrain, assure public safety, return the area to a useful purpose, and improve aesthetic quality. Regardless of the desired post-mining land use designation, reclamation of lands disturbed by surface mining includes the following general stages:

- Backfilling the mined area with overburden
- Re-establishing the approximate original contour
- Replacing topsoil and preparing the surface for seeding
- Spreading approved seed mixtures
- Monitoring vegetation growth and faunapopulations

Additional stipulations are included in site- specific mining and reclamation plans that are approved by the regulatory authority responsible for each mining permit.

4.2 ENVIRONMENTAL IMPACTS OFSURFACE MINING

The main environmental impacts of surface mining include the loss of habitat, erosion, acid rock drainage or acid mine drainage, and dust pollution. These impacts are caused primarily by the disturbance of the ground surface as overburden is removed to access the coal seam. One of the major impacts of surface mining is the loss of wildlife habitat. The disturbance of the ground surface effectively destroys any wildlife habitat in the area. In many areas, mined lands are initially re-vegetated with grassland species to control erosion. This creates a less diverse habitat compared to the pre-mining conditions (USDOI, 2003a).

Habitat loss is typically short-term in nature when reclamation is successful, however long-term loss of habitat can occur for some wildlife species as a result of reduced species diversity on reclaimed lands. The disturbance of large areas of land can lead to erosion via wind and water. Sediment transported by water tends to be deposited in streambeds, and can potentially choke off streams, destroying the habitat. Federal regulations require mine operators to construct sedimentation pools or filtration ponds, through which all drainage from disturbed areas must pass. Diversion walls or banks may also be constructed to direct drainage water away from the mined area (USDOJ, 2003b).

Acid mine drainage, sometimes simply referred to as acid drainage, is the seeping of acidic waters, which are produced when reactive sulfide materials are exposed to water and oxygen and are dissolved. The water that flows away from the drainage site contains high levels of metals, primarily iron, and a low pH. This water then flows into streams or the water table, raising the acidity of the stream and water resources. The lowering of water pH has a negative impact on the environment, stressing plant and animal populations alike. In some situations entire stream systems are destroyed, as water acidity and dissolved solids may become too great for the survival of any aquatic life (Frank, 1983).

Many aspects of coal mining can lead to acid drainage. Acid drainage is routinely found in abandoned underground mine workings which have been allowed to fill with groundwater. However, acid drainage can occur nearly anywhere the land surface is disturbed, and mineral materials are exposed to water and oxygen. Water that flows through coal stocks, waste tailings, and active mining sites can become very acidic and contain high levels of toxic metals. In addition, the construction of roads, railroads, and other mine infrastructure also causes large surface disturbances that may add to acid drainage as precipitation runs off across the disturbed area (USEPA, 2005).

Mine operators are typically required to carefully handle overburden materials containing potentially harmful chemical components. If the material is used for backfilling during reclamation, it must be placed at the bottom of the mine and

covered with clay or another material to seal it from water infiltration. In some cases, the material may be disposed of at another location (USDOI, 2003a).

Air pollution is another major concern for coal mining operations. The majority of air pollution from surface mining operations results from the dust and exhaust emissions of large mining equipment and machinery. Particulate emissions are caused by several mining activities, such as blasting and moving overburden materials and coal. Large areas of disturbed land can also be a source of particulate material, as it is spread by wind. In addition, blasting of overburden material occasionally causes a release of NO₂ gas which can be hazardous to human health (USDOI, 2003a).

5 METHODOLOGY

The methodology, which will be used for finding the change analysis studies, is as shown in the given figure in terms of flow diagram. The Satellite image of 2007 has been scanned in order to convert them into a soft copy and registered using ArcGIS software. Satellite image of 2013 has been enhanced in order to extract maximum information and registered with reference to the registered map. These layers were exported to ArcGIS software. Different attribute layers such as open area, urban area, agriculture area, forest area and illegal surface mining have been generated by onscreen digitization and change analysis will be carried out.

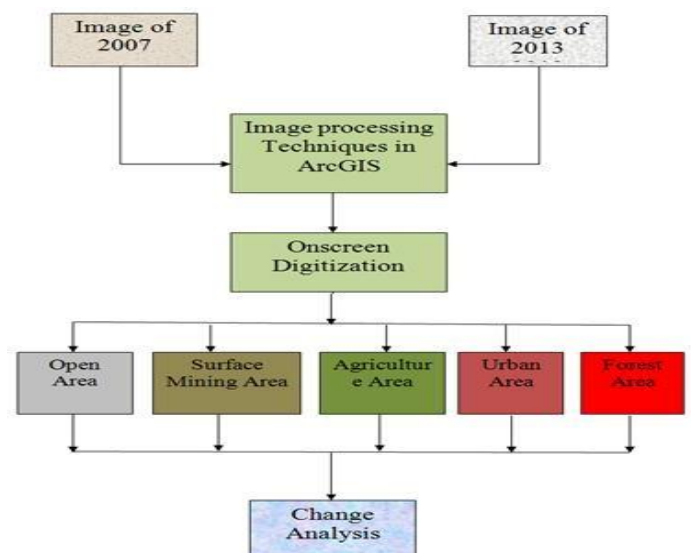
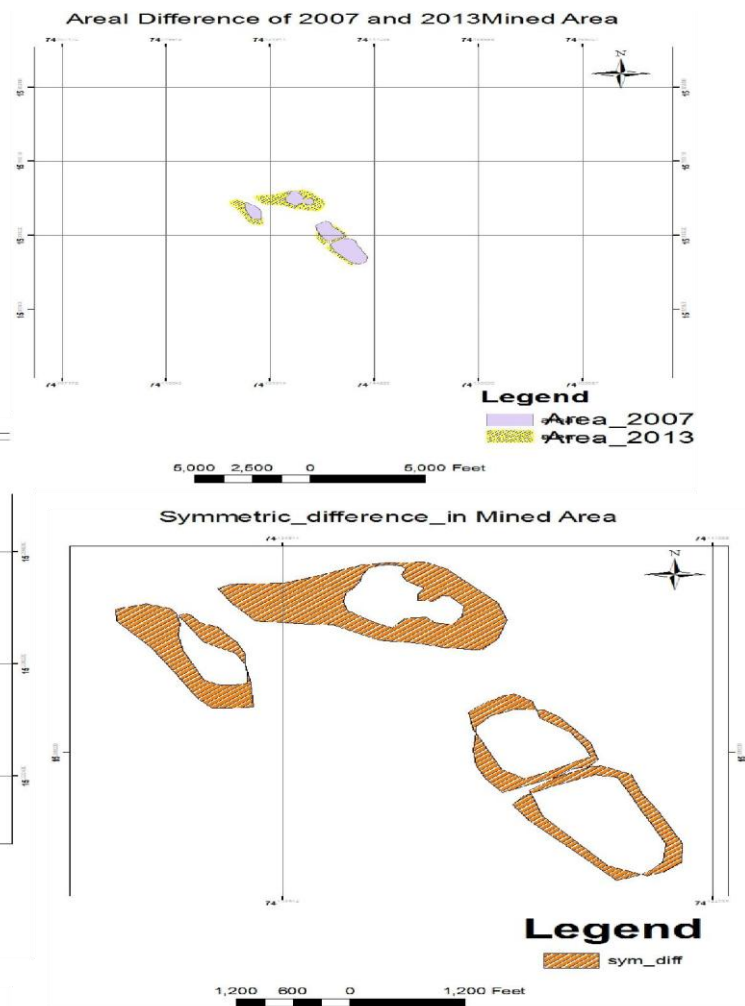
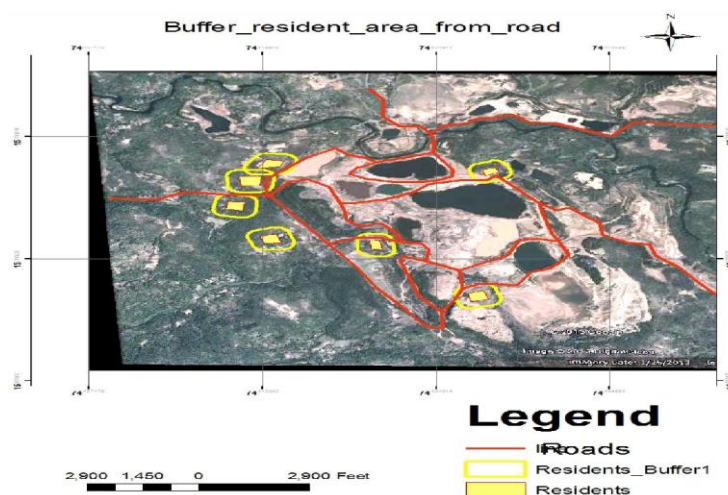
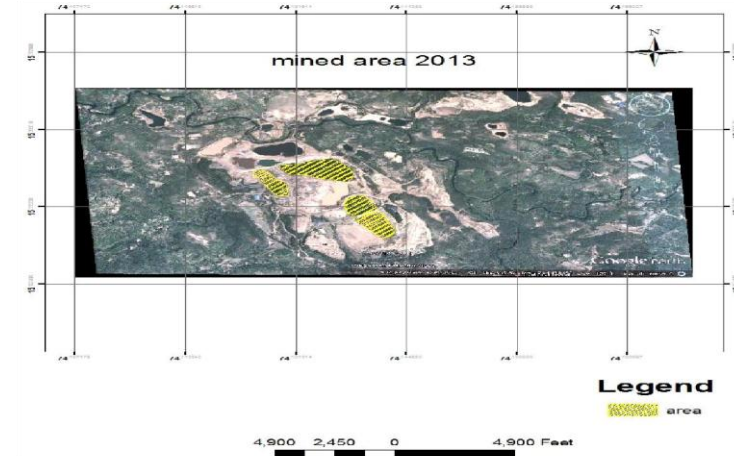
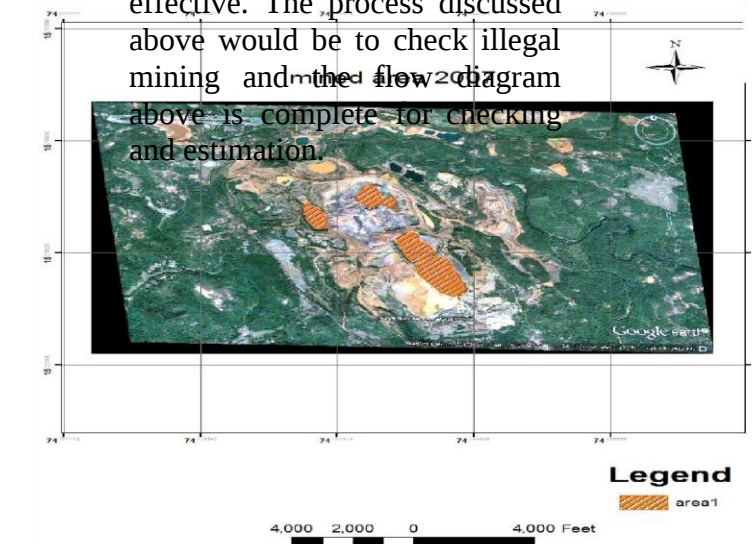


Figure1. Flow diagram showing the change analysis of Illegal Mining

6. RESULTS AND DISCUSSIONS

The following figures and prepared maps of observed and digitized satellite images of different years of same area showing the change analysis. The use of this technique in estimation of illegal mining would be innovative and effective. The process discussed above would be to check illegal mining and the flow diagram above is complete for checking and estimation.



Figures 2-6. Showing the land use change analysis of Illegal Mining from 2007 to 2013

Table 1. Showing the land use change analysis of Illegal Mining between 2007 and 2013

Category	Change (Km ²)	Percentage Change (%)	Remark
Urban Area	35.21	33.50	Increase
Mining Area	5.31	3.17	Increase
Open Area	11.17	9.42	Decrease
Forest Area	4.47	3.57	Decrease
Agriculture Area	9.92	8.54	Decrease

7 CONCLUSIONS

A remote sensing based approach for quantifying primary and secondary impacts of surface mining is presented and applied for the assessment of the mining development in a region. Affected areas were identified as the difference between land cover maps derived from Satellite data (30 m resolution) acquired in 2007 and 2013. Maps produced from remote sensing data provide

information for subsequent impact assessments from surface mining development on land cover, as well as forming the basis for reclamation planning and monitoring. Understanding the cause of variability in vegetation conditions allows for distinguishing natural from human-induced perturbations of ecosystems; an important prerequisite in quantifying environmental impacts caused by mining and other developments.

8 REFERENCES

- [1] George P. Petropoulos, Panagiotis Partsinevelos and Zinovia Mitraka (2012), Change detection of surface mining activity and reclamation based on a machine learning approach of multi-temporal Landsat TM imagery, Geocarto International 2012, 1–20.
- [2] Philip A. Townsend, David P. Helmers, Clayton C. Kingdon, Brenden E. McNeil, Kirsten M. de Beurs, Keith N. Eshleman (2009), Changes in the extent of surface mining and reclamation in the Central Appalachians detected using a 1976–2006 Landsat time series, Remote Sensing of Environment 113 (2009) 62–72.
- [3] Ololade, H.J. Annegarn, D. Limpitlaw and M.A. Kneen (2008), Land-Use/Cover Mapping and Change Detection in the Rustenburg Mining Region Using Landsat Images, IGARSS 2008, Boston, MA, USA.
- [4] Rasim Latifovic, Kostas Fytas, Jing Chen, Jacek Paraszczak (2005), Assessing land cover change resulting from large surface mining development, International Journal of Applied

- [5] Guild, L.; Cohen, W.; Kauffman, J. (2004). Detection of deforestation and land conversion in Rondonia, Brazil using change detection techniques. *International Journal of Remote Sensing*, 20(4), 731-750.
- [6] Lein, J. (2001) Evaluating the utility of land satellite information for strip mine reclamation monitoring and assessment. *Papers and Proceedings of the Applied Geography Conferences*, 24, 1-8.
- [7] Prakash, A. & Gupta, P. (1998) Land-use mapping and change detection in a coal mining area- a case study in the Jharia coalfield, India. *International Journal of Remote Sensing*, 19(3), 391-410.