IMPACT ASSESSMENT OF MINING ACTIVITIES THROUGH CHANGE DETECTION ANALYSIS

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Abstract -*Mining causes massive damage to landscape and biological communities, Plant communities get distributed due to mining activities. The Lime stone has been heavily extracted since ages in Ariyalur district of Tamil Nadu. The forests are the greatest victims of these activities, which can be gauged from the depletion of the forests in all the mine belts. As a result, many parts of the district have been converted from the original lush green landscape to mine spoils.In this study, evaluation of Limestone quarries determined by using change detection analysis since 1979 to 2019. The LU/LC map of Ariyalur district has been generated from temporal images which are obtained from Landsat mission. Three years, data has been taken for this study. Image rectification, fusion & visual interpretation techniques performed to gain the better results, after that GIS database generated and vector overlay performed to find the spatial distribution and changes between the decade intervals.*

Key Words: Change Detection Analysis, Mining, Deforestation, and Environmental Impact.

1. INTRODUCTION

Mining operations, which involve extraction of minerals from earth's crust, is second only to agriculture as the world's oldest and important activity. In a sense, the history of mining is the history of civilization (Khoshoo, 1984). From the pre-historic days, man has been interested about earth's mineral wealth. The crude stone implements of the early paleolithic period, post-Neolithic pottery, the Egyptian pyramids, iron and copper smelting in various civilizations, and the modern steel-age are all testimony of mining activities of man.

The recent development of Remote Sensing & GIS having vital role to access the impact of mining activities and control the ecological disturbance where the mining carried out. Change detection analysis possess better way to study the changes in that particular regions.

2. NEED FOR THE STUDY

In the present study area having huge level of Limestone deposits, it is utilized as a major raw material for cement industries. The limestone mining causes rapid changes in that surroundings. Environment is highly getting polluted and the deforestation rate is very high in this region. These all mining impacts has to be controlled and proper study must be taken for further recommendation.

3. SCOPE OF THE STUDY

The main objective of **"Impact Assessment of Mining Activities through Change Detection Analysis"** to find the expansion of mining boundary and its impact on crop land and vegetation, it tends to control the pollution and rate of deforestation where the mining carried out. It helps to control the ecological disturbance due to mining activities.

4. LOCATION OF THE STUDY AREA

The present study area Ariyalur taluk is located in the SW of Ariyalur district, **Ariyalur** is an administrative district in the state of Tamil Nadu in India. The district headquarters are located at Ariyalur Taluk. The district occupies an area of 1949.31 sq.km and had a population of 752,481 As per the 2011 census. Which occurring in the central part of Tamil Nadu state. It lies between latitudes 10°58 52 *N* TO 11° 35 12 *N* and longitudes 78°56 36 *E to 79°16 22 E* and it is covered in the survey of India toposheets no C44G13, C44B4, C44B8 and C44H1. Total area of the Ariyalur taluk is extended about 682 km^2. it is famous for its cement industries in and around it. This is possible due to its immense limestone store which is the potential raw material for cement industries. Iun particular the Arasu cement, the Birla cements, the Dalmia cements, the Tamil Nadu cements, Chettinad cements etc. are suited in Ariyalur. So Ariyalur is one of the busiest transport cities Ariyalur taluk can be accessed easily by rail and roads. All the sixty-eight revenue villages can be accessed by metalled/unmetalled roads which crossing the state highways.

5. METHODOLOGY

Rectification, classification, GIS integration and presentation were applied to dataset in order to perform aim of the study in an accurate way. Moreover, all process in the methodology were supported by ground truth data and topographic maps. Methodology applied in the study is mentioned in the following parts.

Step-I Data collection

Three different year satellite data has been collected for change detection analysis in which study area being covered.

Step-II Rectification

All that three satellite images have been introduced for geometric and radiometric corrections for further studies. After that resolutions merge performed for generating high resolution images for better visual interpretation.

Step-III Base map

Base map preparation is one of the primary works to know about our study area clearly and it defines the boundary of study area in that all important features are digitized.

Step-IV Classification and LU/LC Mapping

Most satellites that image the Earth provide Spectral imaging. These images may be called multispectral, hyperspectral or ultra-spectral because they are acquired for the same area using different wavelengths of the electromagnetic spectrum. For example, Landsat satellite, Multispectral scanner – band 1 image, band 2 image etc. Since these sensing images are typically multispectral responses of various features sensing data has to be classified first, followed by processing by various data enhancement techniques so as to help the user to understand the features that are present in the image.

Such classification is a complex task which involves rigorous validation of the training samples depending on the classification algorithm used. The techniques can be grouped mainly into two types.

a. Supervised classification techniques
b. Unsupervised classification techniques

Supervised classification makes use of training samples. Training sample are areas on the ground for which there is Ground truth, that is, what is there is known. The spectral signatures of the training areas are used to search for similar signatures in the remaining pixels of the image, and we will classify accordingly. This type of classification which uses the training samples for classification is called supervised classification. Expert knowledge is very important in this method since the selection of the training samples and adopting a bias can badly affect the accuracy of classification. One popular technique is the Maximum Liklihood Principle. In the we will calculate the probability of a pixel belonging to a class (i.e. feature) and will allot the pixel to its most probable class.

In case of unsupervised classification, no prior knowledge is required is required for classifying the features of the image. In this, the natural clustering or grouping of the pixel values i.e., Gray level of the pixel are observed. Then a threshold level is defined for adopting the no of classes in the image. The finer the threshold value more will be the no of classes. But beyond a certain limit same class is represented in different classes in the sense variation in the class is represented. After forming the clusters, ground truth validation is done to identify the class the image pixel belongs to. Thus in this unsupervised classification, information about the classes is not required. One of the popular methods is unsupervised classification is K means classifier algorithm.

Step-V GIS Integration:

After the classification all the data for integrated by using GIS to get vector overlay, mine boundaries and deforested areas are digitized from the classified images and then change detection analysis done by generating vector overlay.

6. SOFTWARE REQUIREMENTS

Arc GIS 10.3: ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database.

7. IMPACT ANALYSIS

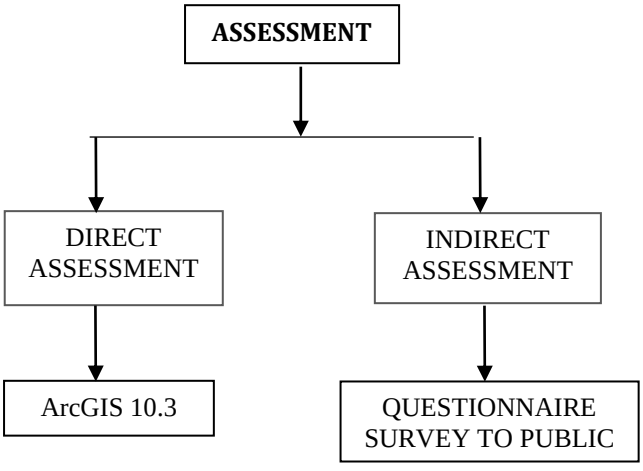

Chart-1: Flowchart for Assessment

7.1 DIRECT ASSESSMENT

7.1.1 BASE MAP

Base Map of Ariyalur Taluk has been prepared from the SI Toposheets C44G13, C44B4, C44B8 and C44H1. These four toposheets hard copies were scanned in 300dpi level for converting to soft copy. After that all these images has been georeferenced with GCS Everest Modified datum in Arc GIS 10.3.

Fig-1: Base Map of Ariyalur Taluk

These all four georeferenced images were mosiced and then taluk boundary has been digitized for knowing the area of interest, after that this mosiced image subsetted based on area of interest. From those taluk boundary Major roads, locations, rivers, Railway lines and some permanent features has been extracted.

7.1.2 IMAGE RECTIFICATION

When image data is recorded by sensors on satellite and aircraft, it can contain errors in geometry and in the measured brightness values of pixels. The latter are referred to as radiometric errors and can result from the instrumentation used to record the data and from the effect of the atmosphere.

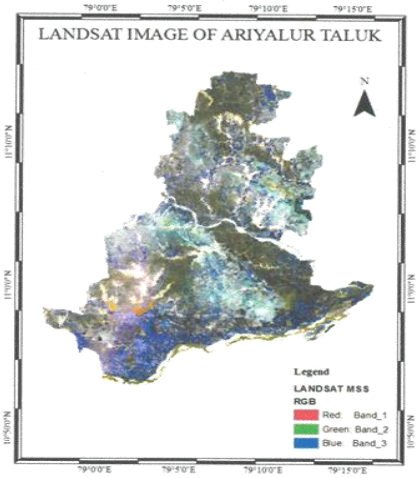

Fig-2: LANDSAT MSS Image

Here the objective of study is to find mine boundary expansion, for that purpose Pre-rectified Landsat mission satellite image date has been downloaded from the United States Geological Survey (USGS) publication prior to any digital processing, all the images were radiometrically normalised. Digital numbers were converted in exo-radiametric responses over time and for variations in the natural conditions of solar irradiance and solar angles. After the radiometric normalisation process, all the images were geometrically corrected. The images were acquired in 1999 was georeferenced to the UTM coordinate system, zone 35 South based on 1: 50,000 scale digital topographic maps 18 control points on the map. The other images were registered through an image to image registration tie down Layer stacking and mosic process performed for all those MSS, ETM+ & TIRS images. After this process all the images were introduced for resolution merge.

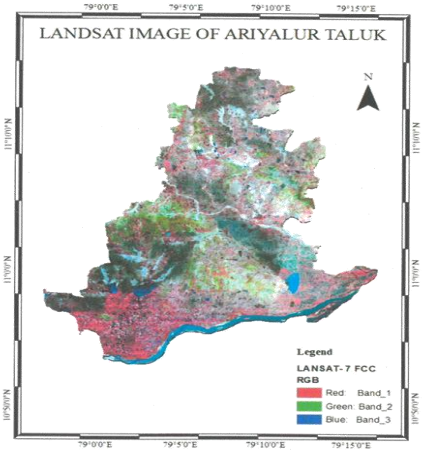

Fig -3: LANDSAT ETM+ Image

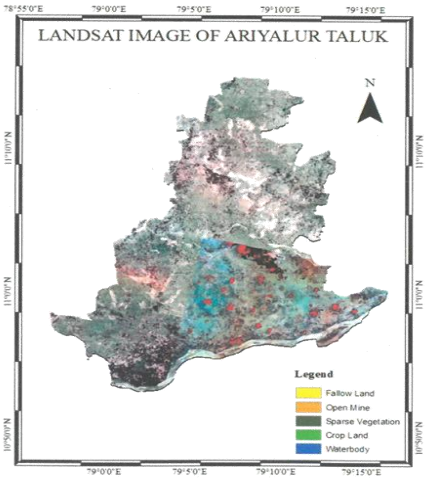

Fig-4: LANDSAT TIRS Image

7.1.3 LAND USE AND LAND COVER MAP

The images "land cover" and "land use" are sometimes used interchangeably, they are actually different. Simply put, land cover is what covers the surface of the earth and

land use describes how the land is used. Examples of land cover classes include: wildlife management area, agricultural land, urban, and recreation area.

Table-1: NRSC Classification Scheme

SI.NO	Class	Sub-Class
1	Built up	Urban, Rural, Mining
2	Agriculture	Crop land, Fallow land, Plantation
3	Water Bodies	River/stream/canal, inland water
4	Barren land	Salt Affected Land, Sandy land, Scrub

7.1.4 BUILT-UP LAND

It is an area of human habitation developed due to non-agricultural use and that has a cover of building, transport and communication, utilities in association with water, vegetation and vacant lands. Web LULC map consists of 3 classes under built-up viz., urban, rural and mining.

Urban: Urban areas are non-linear built up areas covered by impervious structures adjacent to or connected by streets. This cover is related to centers of population. This class usually occurs in combination with, vegetated areas that are connected to buildings that show a regular pattern, such as vegetated areas, gardens, etc. and industrial and/or other areas. (FAO, 2005).

Rural: These are the lands used for human settlement of size comparatively less than the urban settlement of which the majority of population is involved in the primary activity of agriculture.

Mining: Mining areas encompass area under surface mining operation. The recognizable impacts of these activities on the landscape are unmistakable giant pit mines covering vast areas. The presence of water bodies does not necessarily imply inactive or unused extractive areas; ponds or lakes are often an integral part of an extractive operation. (USGS, 1999) It includes surface rocks and stone quarries, sand and gravel pits, brick kilns, etc.

7.1.5 AGRICULTURAL LAND

These are the lands primarily used for farming and for production of food, fiber, and other commercial and horticultural crops. It consists of:

Crop Land: These are the areas with standing crops as on the date of satellite overpass. Cropped areas appear in bright red to red in colour with varying shape and size in a contiguous to non-contiguous pattern. They are widely distributed indifferent terrains; prominently appear in the irrigated are as irrespective of the source of irrigation.

Plantations: These are the areas under agricultural tree crops planted adopting agricultural management techniques. Depending on the location, they are exhibit a dispersed or contiguous pattern. Use of multi-season data will enable their separation in a better way.

Fallow: An agricultural system with an alternation between a cropping period of several years and a fallow period. (Ruthenberg, 1980). In another terms these are the lands, which are taken up for cultivation but are temporarily allowed to rest, un-cropped for one or more season, but not less than one year.

Current Shifting Cultivation Areas: This describes the growing of crops for a few years on selected and clear plots, alternating with a lengthy period of vegetative fallow when the soil is rested. The land cultivated for less than 33 percent of the time (Ruthenberg, 1980).

7.1.6 FOREST

The term forest is used to refer to land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. Forest are determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5m (MOEF, 2011) It consists of:

Evergreen / Semi- Evergreen: This term as such describes the phenology of perennial plants that are never entirely without green foliage (Ford- Robertson, 1971). This category comprises of tall trees, which are predominantly remain green throughout the year. It includes both coniferous and tropical board leaved evergreen species. Semi-evergreen is a forest type that includes a combination of evergreen and deciduous species with the former dominating the canopy cover.

Deciduous: This applies to the phenology of perennial plants that are leafless for a certain period of the year (Ford-Robertson, 1971). The leaf shedding usually takes place simultaneously in connection with the unfavourable season (UNESCO, 1973).

Forest Plantation: These are the areas of tree species of forestry importance, raised and managed especially in notified forest areas. The species mainly constitute teak, Sal, eucalyptus, casuarinas, bamboo etc.

Scrub Forest: These are the forest areas which are generally seen at the fringes of dense forest cover and settlements, where there is biotic and abiotic interference. Most times they are located closer to habitations. Forest blanks which are the openings amidst forest areas, devoid of tree cover, observed as opening of assorted size and shapes as manifested on the imagery are also included in this category.

Littoral/ Swamp/ Mangrove Forest: These are tropical and subtropical vegetation species that are densely colonized on coastal tidal flats, estuaries salt marshes etc. This category includes all the areas where the canopy cover/ density is above 10%.

7.1.7 GRASS / GRAZING LAND

These are the areas of natural grass along with other vegetation, predominantly grass-like plants (Monocots) and non-grass-like herbs (except Lantana species which are to be classified as scrub). It includes natural/ semi-natural grass/ grazing lands of Alpine/ Sub-Alpine or temperate or sub-tropical or tropical zones, desertic areas and manmade grasslands.

7.1.8 WASTELANDS

Described as degraded lands which can be brought under vegetative cover with reasonable effort and which is currently under-utilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes. It consists of

Salt-Affected Land: Generally characterized as land that has excess salt in the soils with patchy growth of grasses.

Gullied / Ravinous Land: They are the resultant of terrain deformation due to water erosion which occurs widely in all agro-climatic zones. Gullies are formed as a result of localized surface run-off affecting the unconsolidated material resulting in the formation of perceptible channels causing undulating terrain. They are mostly associated with stream courses, sloping grounds with good rainfall regions and foothill regions. These are the first stage of excessive land dissection followed by their networking which leads to the development of ravines land. Ravines are basically extensive systems of gullies developed along river courses.

Scrub Land: These areas possess shallow and skeletal soils, at times chemically degraded, extremes of slopes, severely erodes or subjected to excessive aridity with scrubs dominating the landscape.

Sandy Area: These can occur in coastal, Riverine or inland areas. Desertic sands characterized by accumulation of sand developed in situ or transported by Aeolian processes. Coastal sands are the sands that are accumulated as a strip along the sea-coast. Riverine sands are those that are accumulations in the flood plain as sheets which are the resultant phenomena of river flooding.

Barren Rocky / Stony Waste: These are rock exposures of varying lithology often barren and devoid of soil and vegetation cover.

Rann Area: An extensive salt marsh of western India between the Gulf of Kutch and Indus River Delta.

Table-2: Land Cover Distribution of 1979

CLASS NAME	AREA (sq.km)
Open Mine	207.063
Sparse Vegetation	65.72
Crop Land	175.02
Fallow Land	187.386
Water Body	6.4

7.1.9 WETLAND / WATER BODIES

All submerged or water-saturated lands, natural or man-made, inland or coastal, permanent or temporary, static or dynamic, vegetated or non-vegetated, which necessarily have a land-water interface, are defined as wetlands. It consists of

Inland Wetlands: These are the areas that include ox-bow lakes, cut-off meander, playas, marsh, etc. which are seasonal as well as permanent in nature. It also includes manmade wetlands like waterlogged areas (seasonal and perennial).

Coastal Wetland: These include estuaries, lagoons, creek, backwater, bay, tidal flat/ mud flat, sand/ beach, rocky coast, mangrove, salt marsh/ marsh vegetation and other hydrophytic vegetation and saltpans.

River / Stream / Canal: Rivers / Streams are natural course of water flowing on the land surface along a definite channel/ slope regularly or intermittently towards a sea in most cases or in to a lake or an inland basin in desert areas or a marsh or another river. Canal are artificial water course constructed for irrigation, navigation or to drain out excess water from agricultural lands.

Water Bodies: This category comprises areas with surface water in the form of ponds, lakes, tanks, and reservoirs.

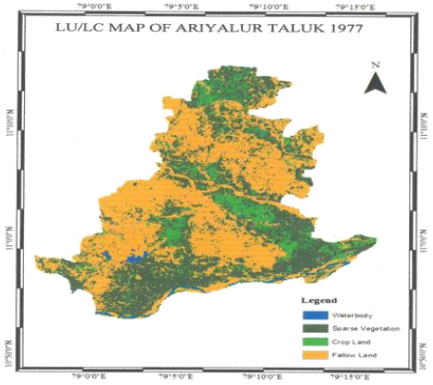

Fig-5: LU/LC Map of Ariyalur Taluk **1979**

LU/ LC Map of 1979 shows that very high amount of vegetation and fallow land,then Open Mine extended about 2.31km^2. It indicates the initial level of Mining activities in this study area. The Southern parts of Ariyalur Taluk densely covered with vegetation. Overall interpretation and analysis gives results of less impact due to mining activities.

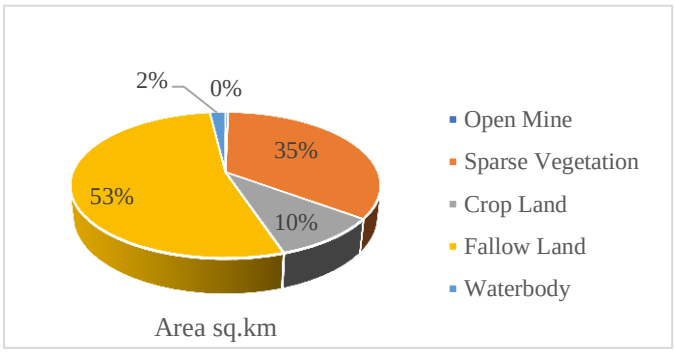

Chart-2: Spatial Distribution of major classes in Ariyalur taluk 1979

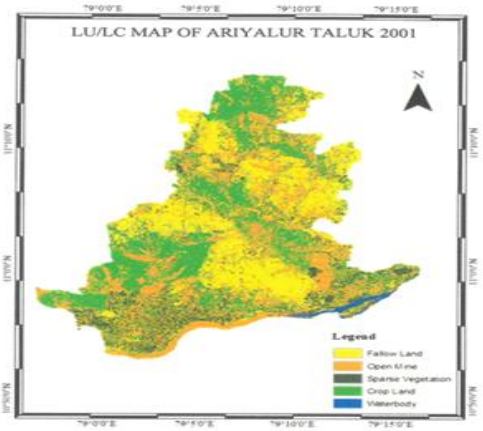

Fig-6: LU/LC Map of Ariyalur Taluk **1999**

Table-3: Land Cover Distribution of **1999**

CLASS NAME	AREA (sq.km)
Open Mine	207.063
Sparse Vegetation	65.72
Crop Land	175.02
Fallow Land	187.386
Water Body	6.4

LU/LC Map of 1999 depicts that very high open minings, it extended about 207.063 sq.km. this is the remarkable period in growth of mining activities most of the crop lands are shifted to mining and mine dump areas.

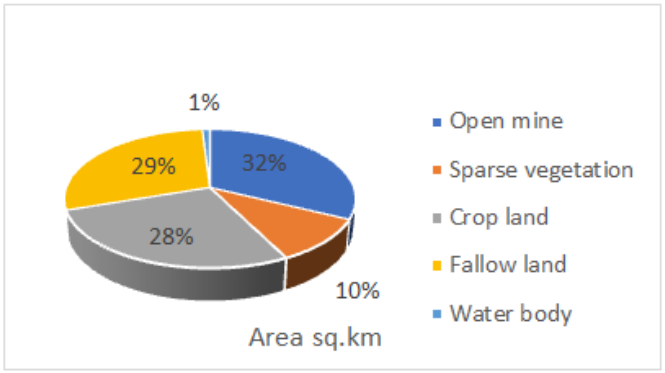

Chart-3: Spatial Distribution of major classes in Ariyalur taluk 1999

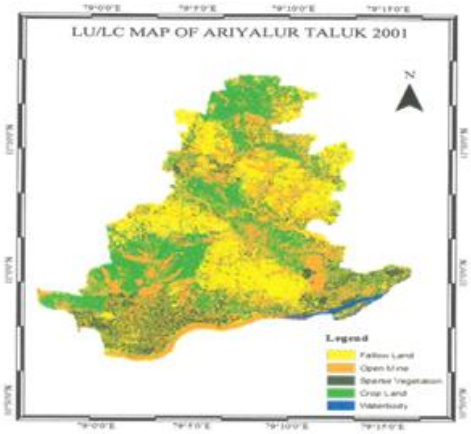

Fig-7: LU/LC Map of Ariyalur Taluk **2019**

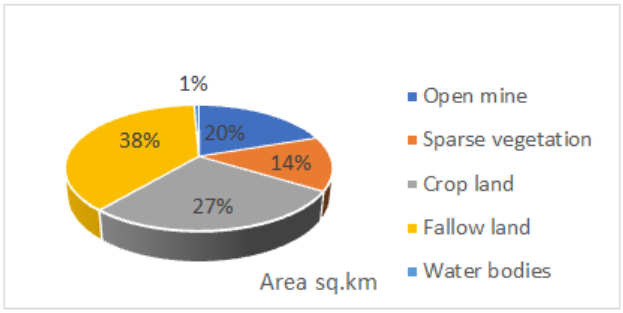

Chart-4: Spatial Distribution of major classes in Ariyalur taluk **2019**

7.1.10 CHANGE DETECTION ANALYSIS

Change detection analysis has been performed for the years 1979,1999& 2019. These entire year GIS data has been generated and vector overlay performed to find the expansion of Mine boundary. The Fig 4.8 shows the Changes of major features over the Ariyalur Taluk.

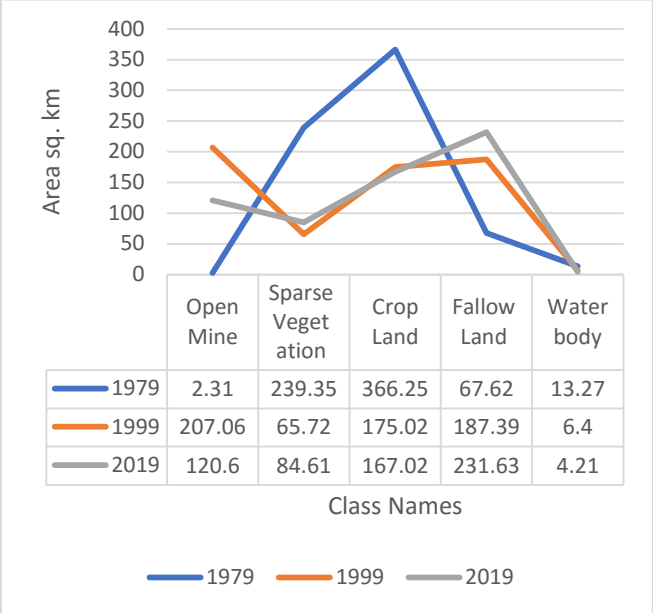

Chart-5: Change Detection Analysis

7.2 INDIRECT ASSESSMENT

QUESTIONNAIRE SURVEY

This questionnaire survey is mainly conducted in Ariyalur taluk where the mining works has been done under our study area. Out of the questionnaires given to the participants of the survey, 100 responses were obtained. The results have been grouped under five categories:

- **I.** Health issues
- **II.** Surface cover issues
- **III.** Water bodies
- **IV.** Job oppurtunities
- **V.** Environmental impacts.

The above has been done to identify the problems has been faced by surrounding peoples. And also environmental impacts were assessed. As the responses obtained all those categories were analysed properly

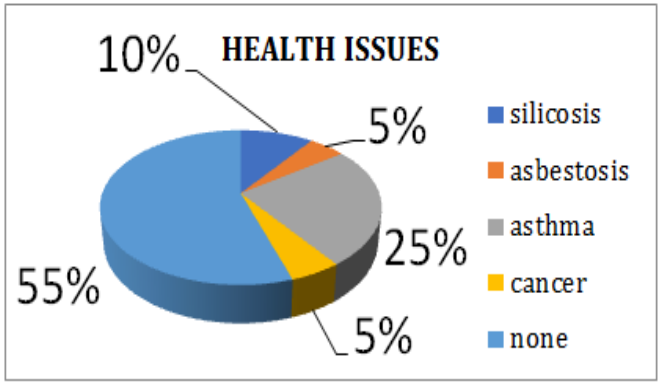

Chart-6: Results for Land Suffer

I. RESULTS FOR HEALTH ISSUES

As observed from the pie chart shown in Fig. Almost the 55% of peoples were not affected by any other health issues. From the affected peoples, most of them were troubled by Asthma problem due to air pollution from the mining areas. The remaining health problems were affected for minor number of peoples in Ariyalur which shown in following pie chart.

II. RESULT FOR LAND SUFFER

The survey about land issues clearly shows that the most of the lands were affected due to mining works done in Ariyalur taluk. The major suffers were contamination of soil, instability of soil, loss of bio-diversity, soil erosion, etc.,

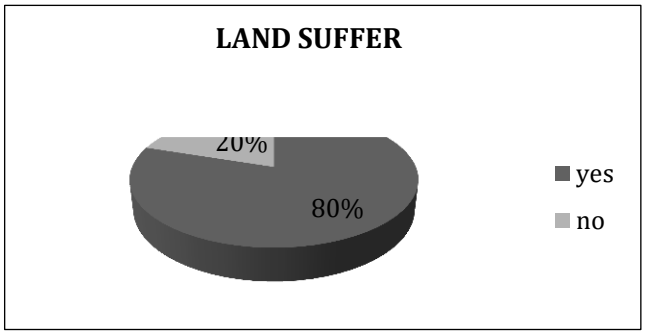

Chart-7: Results for Land Suffer

III. RESULTS FOR WATER BODIES

As per the survey taken on the study area about the groundwater issues, it confirms that the groundwater source was heavily polluted due to extraction of limestone.

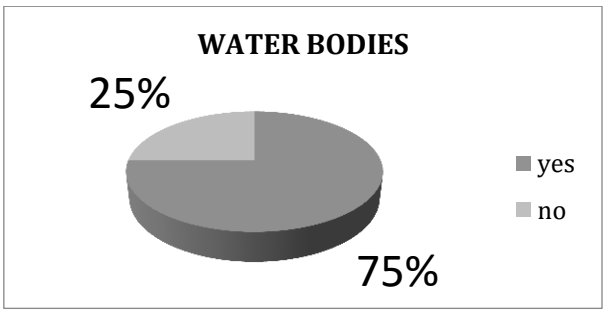

Chart-8: Results for Water Bodies

IV. RESULT FOR JOB OPPURTUNITIES

Government provides several job offers to the local peoples according to their qualification. Rest of the people who's lands acquired by the industries, were settled.

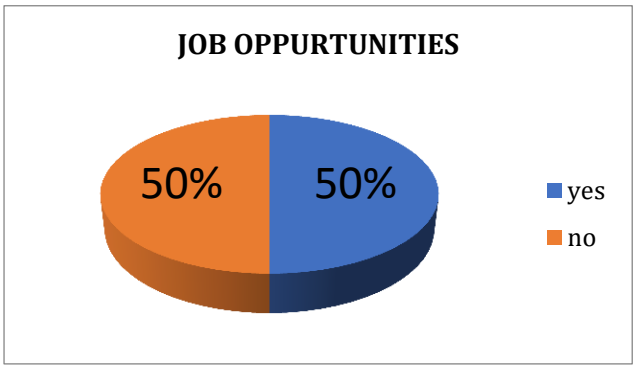

Chart-9: Results for Job Oppurtunities

V. RESULT FOR ENVIRONMENTAL FACTORS

Most of them agreed that there is a lot of environmental issues majorly affected in the area.

Some of them are

- Air depletion
- Water scarcity
- Deforestation

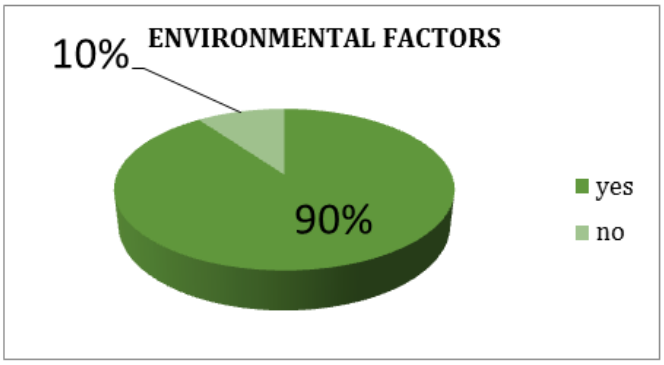

Chart-10: Results for Environmental Factors

8. REMEDIES FOR IMPACT DUE TO MINING

a. Closing illegal and unregulated mines

In context with enforcing regulations and maintaining steadfast legislation regarding a mine's behavior and processes, the strict and swift closing of illegal or unregulated mining activity will set an environmental precedent within the industry.

b. Scrap mining and recycling

On a global scale, mining corporations around the world are discovering efficient ways to capitalize fully on materials in order to provide the goods and services people want using much less wood, metal, stone, plastic and other materials. By reducing the amount of wasteful use on a public and private level, and by steering production towards the sole use of durable goods that can be easily reusable, re-manufactured, or recycled, the mining industry can begin to reduce its impact on an international scale.

c. Accurate tallying of toxic mining waste

Another problem with the whole sustainable mining debate has to do with secrecy in reporting toxic mining waste. Mining companies have not been accurately reporting the amounts being dumped into the environment and in doing so, have kept the public in the dark. Most notably this has been occurring with the Canadian people as of late, with a huge public backlash being the center of much of the mining industry controversy being targeted on accurate waste tallying lately. While sustainable mining looks good on paper and seems easy enough to follow provincial or federal guidelines, the industry has a way to go before it can be considered even remotely green.

d. Building from reusable waste

Not only can mining present a hazard to the environment, but it can also be seen as a toll on public health if appropriate measures are not taken to ensure that the mining process is being done as safely and efficiently as possible. Case studies from mines around the world have provided numerous success stories of corporations and private mines alike being able to build new construction and infrastructure from the reusable materials that a mine site presents. For example, aluminum can be substituted as a recyclable material rather than using bauxite ore, which is a rarer and less reusable item.

e. Replenishing the environment

A seemingly simple but rarely prioritized activity, replenishing mine sites and mine environments is one of the key factors to not only earning the respect and cooperation of those living near the mine, but will ultimately protect the mine's impact on the environment. Simple solutions like replenishing native soils and grasses, cleaning excess waste, proper waste removal, site inspections and replanting trees and natural forestry can rejuvenate a long-term ecosystem repair and sustain the environment for years beyond when the mine is no longer operating. The entire reclamation process should include: removing hazardous materials, reshaping land, restoring topsoil, and planting native grasses, trees or ground cover natural to the site.

9. CONCLUSION

Within the framework of this study, for the detection of Mine boundary expansion and Impacts of Mining activities in Ariyalur Taluk using Landsat data was realized. The digital image classification conducted with GIS, it has

proved ability to obtain comprehensive information on the direction, magnitude, and location of land cover changes as a result of mining activities. Results of the study show that mining activities have significant effects on the environment. Especially in Ariyalur Taluk these effects have not seriously taken in to consider. Although mining activities should be organized by terms of sustainable development, mining activities have been executed illegally. This study concludes that most of the crop lands are shifted mine dumbs. New cement manufacturing companies spreads the waste in Ariyalur taluk. Mining activities are very high in the year 1999, Open mine area extended up to 207.06 sq.km in this period later it gradually decreased up to 120 sq.km due to the completion of ore deposit. Most of the ore deposits got over and afforestation takes place in 2019. Most of the crop lands are shifted to mine dumps & Open cast mining zones.

The impact of mining activities is

- ✓ Crop lands are shifted Mine dumps and Open mine excavating areas.
- ✓ Rate of fallow land increased up to 231.63 sq.km in the year 2019
- ✓ Water bodies as lakes, ponds, tank area gradually decreased from the year 1979 to 2019, finally it has decreased to 4.21 sq.km, it causes the increasing rate fallow land.

In this concept, the distribution and expansion of these activities should be monitored, their environmental damages should be determined, mitigation studies against these damages should be performed, and regular inspections should be executed to keep these activities under control. Modern technologies should be used to obtain more effective results from these studies. Although monitoring the changes in large areas by using conventional method is very difficult, remote sensing is the most convenient technique to collect a large amount of data for this kind of areas. With the ability of satellite data, it is possible to detect and analyse the magnitude and spatial changes of natural environment which is significant for resource managers. Additionally, GIS technique is used to summarize changes in the spatial distribution of land cover classes by overlaying map of different dates and analyse their spatial coincidence for helping in decision making process in order to project future land development.

10. REFERENCES

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