3.3 Damage to land and land-use mining

General effects

The human activities which are instrumental in creating land degradation are mainly deforestation, cultivation, grazing (specially over-grazing), construction (buildings, roads, etc), disturbing water regime and mining. Mining comes at the end of the list if the land area directly put under mining is considered, but its ancillary activities include all the others (except grazing) in the list, each of which takes active role in the cycle of land degradation (Figure 1a, after Ghosh, 2000, pp.273) Cultivation is not an ancillary activity of mining, but, immediately after land acquisition uses of acquired land are to be shifted to a new place. This needs taking new lands under cultivation.

Related effects

Importance of the subject lies on the fact that mining and its ancillary activities damage not only land but almost all other aspects of environment as summarised next. This is because these either thrive on land or exist in juxtaposition with land.

Air	:	Gets disturbed by blasting, excavation, transportation and dumping of excavated out products normally and specially in dry season by getting the lighter ones blown-up by wind.
Water	:	Surface water quality and quantity gets disturbed by pouring & siltation of excavated materials and by products of mining and related activities, while ground water(GW) quality and quantity gets disturbed by infiltration and GW withdrawal.
Flora & Fauna	:	Land-water-forest ecosystem gets disturbed and hence the flora-fauna also.
Aesthetics	:	Scenic areas are changed into barren depressions and elevations.
Socio-economics	:	Forest, agriculture and other land-uses are disturbed and so also the sources of income of the people are lost.
Culture	:	No doubt cultural resources are protected from any such disturbance, but the effects on socio-economics, aesthetics and ecosystem may endanger the existence of cultural resources.

Damage by mining

Impact of mining on land and land use starts at the time of land-acquisition and continues up to use of the mined-out product, as is being detailed next.

3.3.1 Land-acquisition and vacating

Immediately after acquisition of a piece of land for mining, the pre-mining uses of the acquired land needs shifting. This may need construction of houses and other facilities for the displaced people, which, in turn, needs a new land, which may cause damage to greenery and require excavation of land. Further, the rehabilitated people try to grow their food at the new site and hence have cultivation on any small piece of available land. All these increase erosion potential of the region which fills up gradually the surface water bodies through siltation . This decreases the irrigation potential of the region. Some of the lands which were probably having two crops every year (one rain fed and the other by irrigation) will now have only one crop in monsoon and will remain barren for rest of the year.

Barren lands in dry season get exposed to scorching sun and wind, get further dry (by losing soil moisture), get more prone to erosion and hence get eroded. Water from below water table rises partially through capillary rise to near surface and gets evaporated in turn creating loss of GW.

In the next monsoon the surface runoff will carry soil particles (more in quantity than the pre-acquisition days), increase turbidity and siltation of surface water bodies resulting decrease in infiltration potential and water holding capacity of these.

The cumulative effect after some years will be loss of fine soil particles (which hold major part of soil nutrients) hence loss of greenery growing potentiality of the region and hence aggravated erosion potential. The land will gradually lose a thin film of soil from its top. In the long run (may be after hundreds of years) the water table also will go down. The process will run increasingly in a more aggravated speed and push the land gradually towards degradation and lastly desertification. The total process is given in Figure 1b (after Ghosh & Rani, 1999).

As all the pre-acquisition land-uses get shifted from the acquired land, the quality of all environmental attributes including the societal conditions and the quality of life of the people living there gets disturbed.

3.3.2 Deforestation

Mining needs clearing the acquired land which in most cases need deforestation, which invites land degradation as detailed in Figures. 1a and 1b. Among the odd activities required for mining, the most prominent, effective, inevitable activity is deforestation while its long-term effects, i.e. land degradation and desertification are indirect, and hence, to some extent intangible, but these produce most serious effect. Utilities of greenery to in preventing land degradation has been detailed in section

3.3.3 Excavation

Impact of mining on land, due to excavation depends upon the type of mining. Broadly there can be two types of mining depending upon the depth of the deposit to be mined, namely surface (OC) mining and underground (UG) mining. Examples of OC mining are the Kudremukh iron mines in Western Ghat region of Karnataka, Noamundi iron mines in Bihar, Jhamarkotra phosphorite mine in Udaipur, Rajasthan may coal quarries and Raniganj and Jharia coal fields etc.

There may be broadly two types of OC mining depending upon terrain conditions, these are “area strip mining” and “contour strip mining”. Contour strip mining refers to the method which exploits the minerals by excavating along the contour lines on hill slopes or mountains while area strip mining is the method applied on rather flattish terrains. Further, UG mining can be of different types depending upon the characteristics of the deposit specially its mode of occurrence. Each of the varieties of mining are hence being considered separately.

A. Area strip mining

In outline, the method involves stripping away the overburden (if present) and to recover the mineables by use of bulldozers, scrapers or by manual operations. This obviously forms great scars on land at the site of excavation and large piles of overburden (OB) material where the waste is dumped. This results land degradation and land pollution at the excavation site and also at the dumping site.

OC mining needs excavation of land surface. It obviously degrades the quality of excavated land as it gets lowered from its original topographic height. Soil profile in the region gets disturbed and hence the soil quality, its chemical and physical character, behaviour with water, none remains as it was in original condition, because a huge mass of land is excavated out from its original site and placed at a new place. The quarries generated by excavation if left unreclaimed, that amount of land becomes useless.

The nature of degradation varies with depth of excavation. There may be cases of OC mining which create only shallow depressions on land but no OB. Examples of these are mainly stone quarries and clay scrapping for brick-klins. Impacts of these on land are mostly ignored because of shallowness of the quarries; while the fact is, these disturb the topography sufficiently to disturb the surface water flow pattern i.e. the surface water potentialities of the region. Clay scrapping specially causes loss of topsoil and hence greenery growing potentialities of the region. All these add to the land degradational cycle (Figure 1b).

If the depth of excavation is such that it damages the upper part of the aquifer underground, water flows into the excavation site continuously from the remaining part of the aquifer. It continuous pumping out of water from that site to facilitate mining. Land degradation due to this has been detailed in section

In some other cases where the quarry is deep enough to excavate out the total aquifer in the region, its consequences may create damage to water table regional lowering of water table and hence drying-up of land and land degradation. This excavation of aquifers generate a persistent problem. Even when the quarry is backfilled in the name of physical reclamation, it is filled with a material too loose to represent the impermeable layer that was existing at the base of the aquifer. Thus the aquifer is never regenerated (Fig.). This creates a situation which goes against sustainable greenery growth over this mining degraded land, even after so-called biological reclamation.

B. Contour strip mining

Such mining exposes fresh surfaces on sloping land and hence makes these highly prone to rain wash, weathering and erosion, which results siltation in the surrounding area’s land and water system. Such weathering and erosion may even cause water pollution and hence chances of land degradation. Further, if among the minerals involved there exists pyrite, marcasite, ankerite, siderite etc, which will produce sulphuric acid and other soluble salts such as sulphates and oxides, all these may effect adversely on flora, fauna and chemical characteristics of the land, hence land-use and land quality. This aggravates land degradation by two ways:

- Siltation together with chemical pollution in water bodies adds to the cycle of land degradation already explained in fig. 1a & 1b.
- Rolling of broken mined out (but not used) pieces of rock from hill slopes creates land degradation just as an OB-dump detailed next.

Added to the wastes generated by mining is the debris produced in the construction of roads required for mining related activities which damages land just similarly.

C. UG mining

Excavation for UG mining does not create any direct impact on land other than making dumps of materials excavated for reaching the deposit, and the materials excavated with the deposit as gangue mineral. The matter of subsidence is being dealt separately.

There may be different types of UG mining depending upon mode of occurrence of the material to be exploited:

(a) If it is a bedded deposit, it is approached by shaft or incline as the case may be and then only the deposit is mined

(b) If it is a vein deposit it is to be approached almost similarly but at the time of exploitation the total vein is to be excavated out which requires, in some cases (e.g. quartz-mica veins, gold-quartz veins etc.) excavating some unwanted (gangue) minerals together with the desired ones (ores).

(c) If the desired material occurs disseminated in pore-spaces of the country rock (e.g., water etc.) the mineral is to be gained mainly through drilling or pumping (as the case may be), it creates minimum land degradation through excavation other than damage by drilling and ancillary activities. However long continuation of such action may result subsidence.

Deeper OC excavation on land or UG digging causes damage to aquifer and the WT to sink locally, often drastically, resulting in the drying up of wells and springs of the neighbourhood; at least the perennial ones may be altered to seasonal. In case of contour strip mining, subsequent land slides may expose passages of UG water, thus depriving the springs which were being supplied from the source. Some such situation has deprived the Sahasradhara seepage of Mussoorie hills, altering land quality of the region.

3.3.4 Overburden dumping

Amount of OB generated depends upon the mode of occurrence of the deposit. The huge mass of material which lies above the mineral deposit needs excavation during OC mining. These are left over the land in the form of OB dumps. These occupy large amount of land, which loses its original use and gradually gets its qualities degraded. If uncared, these create greater damage to the surrounding lands by several processes :

a. The dumped materials gradually roll down to the surrounding land, disturb the men, materials and uses there by hurting these by big pieces of OB, covers a major part of the land and degrades its quality, by its physical presence as well as by its chemical composition.

b. The OB may contain materials soluble in slightly acidic water (as in acid rains). These may get spread over the surrounding land and poured in the receiving water bodies. This may result water pollution and more land degradation in turn producing acidic, alkaline or saline land by direct wash-off-running or due to using the polluted water for irrigation.

c. As the dump is generally loose, fine particles of it become highly prone to blowing by wind. These get spread over the surrounding plants and disturb their growth, specially sprouting of fresh leaves.

d. The dump is generally loose, highly prone to rain-washing, weathering and erosion. Fine particles generated out of these get spread over the surrounding land and water bodies. Thus the water bodies get their turbidity increased, increased siltation, decreased water storage capacity, gradual drying, following to land degradation as detailed in figures 1a & 1b. The land which receives eroded and washed fines, gets covered by these, which also damage the land’s infiltration potentiality and greenery growing potentiality.

3.3.5 Pumping out of mine water

Any excavation may damage aquifer in the region and invite huge volume of water in the excavation site. This necessitates pumping out of mine water and several consequences on land as detailed below.

- Pumping out of huge volume of water from certain points may create local lowering(s) of water table (WT) in the form of cone(s) of depression (Fig.). This may ultimately result regional lowering of WT and aggravate the process of land degradation as detailed in fig.1b.
- This pumped out water, if poured on land, provides a chance of additional evaporation and disturbs the natural hydrologic cycle and hence invites lowering of WT and hence land degradation.
- The pumped out water if poured on water bodies flowing off the region, the water flows away and goes out of the region

causing depletion of water resources, hence lowering of WT and hence land degradation.

- The pumped out water may contain any soluble mineral brought from the rocks at its original residence at depth (Hammer & Mackichan, 1981). This when poured over a land or a water body or used for irrigation, the receiving body gets polluted.

3.3.6 Haulage, storage & transportation

Excavation is followed by haulage, storage and transpiration of excavated materials. All these activities create air pollution, water pollution, damage to greenery in the surroundings and hence land degradation due to spreading of the fine rock and mineral particles.

3.3.7 Treatment and use

These are done through various processes depending upon chemical character of the ore. Most of such treatments produce some byproducts which, if not used-up, form a huge dump of waste creating land degradation just as the OB dumps. In this reference mention may be made about the followings :

- In central Florida large scale phosphate mines exist. The rocks from the mines are processed to produce phosphoric acid. Further phosphogypsum is produced as a by-product of processing phosphate rock to produce fertilizer chemicals. For each ton of phosphate rock processed approximately 0.5 tons of phosphogypsm is produced. The standard method of disposal of this phosphogypsm is to form stacks on land.
- In early mining of iron-ore from the Adirondack mountains, it was noted that the ore was associated with ilmenite (T_iO_2). The rock that contained a high concentration of ilmenite was being discarded to form of huge tailing pile, until after world war II when new uses of Ti in paints were discovered, so that the old tailings were reworked for ilmenite and partially used up. (Coates 1981, pp.)
- As per Valdiya (1987, pp.149) by A.D. 2000 India will be mining annually 7 Mt of copper ores. The yearly production of tailing will amount to 36,50,000 m^3 or nearly 40 M m^3 in 20 years. The problem of disposal of the tailings would be equally acute.

- Many valuable minerals e.g. gold, diamond etc. are mined from even two miles depth. Tailings separated from the ores excavated with these are dumped in unsighty piles. Also dust and water coming out of these are sources of land degradation..
- Ore of Aluminium is bauxite, which contains iron and occurs in association with ferruginous bauxite. The bauxite needs treatment to get aluminium. It has been observed that, on an average treatment of 1 ton of bauxite releases as byproduct about ½ ton of red mud (Sharma, 1982). It has been estimated by some environmental geologists that by 2000 AD India will produce 10 M m^3 of red mud. Which on spreading can disturb physical and chemical quality of huge amount of land (the actual amount of land disturbed will however depend upon topography).
- At Kudremukh mines western ghats more than 13 Mt of dominantly siliceous tailings are produced per year (Valdiya, 1987).
- At lead-zinc mines the spoils produced are highly toxic, particularly if the metal content is >1,000 ppm.
- If water gets polluted, it is able enough to create land degradation. Cases of river pollution due to mining and ancillary activities are common. Mention may be made of Bailadila iron ore mines site at Kirandih in Bastar district (MP). More than 12 Mt of ore fines had accumulated here in a time span of ten years, 1977-1987 (Valdiya 1987). The rains washed the wastes down stream turning the river near about red .
- The Tiri Stream, which drains the lead mines at Zawar in Rajasthan, was noted to be polluted for 15 km downstream. As a result of lead and zinc pollution, not only the aquatic fauna was adversely affected, even the timber plants and other vegetation had registered perceptible decline. A similar situation was discernible around Jhammarkotra phosphorite mines near Udaipur and in the Khetri copper mines in Rajasthan (Valdiya, 1987).
- The magnesia dust at Jhirauli and Chandak mines generated by calcination plants had caused disappearance of a few species of shrubs like Beriberis (Pant, per. Sound communication, 1982 in Valdiya, 1987, pp.157).

- Mining, handling and dealing of radioactive minerals bear chances of spreading of radioactive emanations on all matters in the surroundings. This may disturb greenery and land characteristics of the region inviting land degradation.

3.3.8. Subsidence

Subsidence is defined as any movement at any place in the earth's crust or on the surface due to any natural and/or manmade activity (Saxena et al. 1989). Such situation may develop due to many causes, natural or manmade, among which those related to mining are as listed below :

- Underground excavations for mining
- Open excavation for mining.
- Pumping and withdrawal of liquid (water) from UG.

Subsidence due to UG mining is an often-heard phenomena. It takes place due to disturbance caused in the superincumbent strata due to extraction of materials from UG resulting loss of support in some cases. It may happen also due to the disturbances in the aquifers due to UG excavation, aquifer compression or aquifer loss detailed next.

In OC mining subsidence, in technical sense, is caused due to slope failures. Such situations if occur in land below the general contour in the region it amounts to slides of quarry faces (of area strip mines) and hence degradation of that much land only, and loss of support of the land beside it. If such situation occurs in case of contour strip mining, the subsided matter falls on the regional contour, damages its physical and chemical characters and disturbs the landuse and landcover of the region.

Pumping of water from aquifers is an activity that causes subsidence. Such pumping may be due to pumping of ground water that flows into the site of excavation for any mineral, if the excavation behades any aquifer. Extensive ground water withdrawal for water use for any human purpose also may cause alike problems. The aquifers hold water at a certain hydrostatic head and the stresses are in the state of equilibrium in natural condition. As soon as pumping of water is started from the aquifer, a drawdown zone develops around the pumping site causing reduction of hydrostatic pressure around. As a result of this the stress equilibrium is disturbed. If such situation retains years after years the equilibrium is regenerated by some grain to grain rearrangement to rename the fire pore spaces in the strata by lowering of WT, thus to compensate the loss of hydrostatic pressure and the aquifers get compacted under the stress due to the load of superincumbent strata. The compaction manifests on the surface in the form of land subsidence. Once the aquifer attains such situation it cannot be recharged by natural process because the porosity to hold the water had already been lost through compaction.

Whatever may be the cause and amount of subsidence, it disfigures topography of the region and alters the drainage conditions, runoff pattern, hence transportation pattern of soil particles and hence the water regime. The quality (physical and chemical) of the land obviously gets disturbed. In case of subsidence below ground, i.e. due to UG mining and ground water withdrawal the lowering of land by subsidence may be a phenomena to manifest long after the withdrawal and in some cases beyond the scope of calculation. This may produce limited time and hence limited scope to reclaim the land damages.

3.4 The cumulative effect

Effects of mining etc.

Whatever impacts of mining and its related activities on land and land related environmental attributes have been explained so far in section , all ultimately produces any of the three effects i.e., damage to land, damage to greenery or high erosion. These three occupy important positions in the cycle of land degradation (Figures 1a and 1b) already explained. These are continuous cycles, which work in repetitive manner so long not stopped by some strongly effective action, and pushes the land towards desertification.

It is thus very clear that all impacts of mining on land and land related environmental attributes join together and multiply the effects to push the land towards desertification.

The matter could be explained in other way, that mining damages greenery as well as water resource is a well accepted fact now a days, while these two natural resources are capable to protect all aspects of environment. Plants improve air quality, water resources, aesthetics, provide food and source of earning, hence in turn improve the level of biodiversity, quality of life and quality of ecosystem. It prevents noise and vibration, flood and draught and hence protects land.

Utilities of greenery in this respect can be listed as follows :

- When properly utilized, forests act as climatic stabilisers, inhibit flooding and sedimentation.
- Cooling capacity of one full-grown tree equals that of five average air-conditioners operating 20 hours a day (Coates 1981, pp 512).

- By taking part in evaporatespiration plants keep the hydrologic cycle running.
- Tree roots provide extra shear strength to the soil particles to resist gravity movement and surface erosion on slope as well as on flattish land.
- The green canopy dampens raindrop impacts on land.
- Trees' litter makes a spongy cover on land and hence a barrier between eroding agents and land, this reduces erosion potential
- The decaying vegetal matter enriches the nutrients in top soil, increases permeability and allows more infiltration, hence lesser in-off and lesser erosion.
- Tree roots provide avenues for additional infiltration. Hence these together with decaying vegetal matter minimise direct runoff and prevent sheet flooding and erosion.

Deforestation negates all the above helps that forests provide for land protection. Hence deleterious influences on land that are created by deforestation are

- increased erosion & soil loss
- increased sedimentation with all its accompanying damages
- disturbing the hydrologic regime by lowering water table and
- loss of soil nutrients.

Observation on effect of deforestation

Some data on effects of deforestation (Coates, 1981) on has been detailed in section 2.3. the extent of land degradation in India has been detailed in section 3.3. Further, that rainfall erosion on OC mined lands bears an importance in ecological perspective is clear from other scientists also (Nicolau & Asensio, 2000).

That effects of erosion is more effective in catastrophic storms in hilly terrains is proved by the set of data (Ives & Messerli 1989) on rate of erosion in

- Ganga/Brahmaputra watershed 0.70mm/yr. (after influx to Bay of Bengal from)
- Darjeeling area 10-20 mm/yr (in catastrophic storms)

The seriousness of erosion rate in India is clear from the fact that if the sediment load of top fire rivers of the world are compared, the three rivers in the list are those which pass through India. This is revealed from table .

Table : Sediment land of top fire rivers of the world (c.f. Hdemon, 1968)

River name	Location	Sediment load (million ton)
1. Yellow	China	2080
2. Ganga	India & Bangladesh	1600
3. Brahmaputra	China, India & Bangladesh	800
4. Yangtze	China	550
6. Indus	India & Pakistan	480

A later data (Narayan & Babu, 1983) however reveals slight decrease in sediment load of rivers passing through India, i.e. Ganga 586 million t/year, Brahmaputra 470 million t/yr., and Indus 106 million t/yr.

It has further been estimated (Agar wal & Narain 1991) out of the total soil loss from India which is about 5334 million tons, approximately 61% gets deposited in rivers, about 10% gets deposited in dams and 29% is lost to sea. It is a serious loss and definitely helps and degradation in India. Further it is a point to realise that a part of this problem (though may not be major) is contributed by the mining and related activities, mainly deforestation, loosening and baring the land surface.

3.5 Case studies

Impact of contour strip mining on land

Probably the most important and first official record of impact of OC mining on land that was refused to be accepted by the population around was the problem of contour strip-mining at Dehradoon. The practice of such mining is that soil together with OB is scrapped off and pushed downslope. Sliding of great volume of debris damages habitations, vegetations, waterbodies, springs etc and whatever exists at the base of the sloping surface.

Such mining in the Mussoori hills over Doon valley have resulted ugly scarification on slope, drastic reshaping of the landscape and serious destruction of forests in the region. It was mining of limestone and dolomite in Dehradoon over a stretch of 40 km from Banog-Cloud End in the northwest to Rani-Pokhri and Sera in the south-east. The problem was aggravated by the principle being followed. The mine owners were picking up only the very high-grade material and discarding the rest. Thus more than 30% of the valuable ores were being discarded and thrown off to slide down the 30^o-50^o slope. In rainy seasons, such rejected loose materials were getting saturated with rain water and forming debris flows descending into the valleys, clogging the channels there, namely Nun, Kiarkuli, Rispara, Baldi and Song, and spreading over fields. According to the estimation of the U.P. Directorate of Geology and Mining, about 1.7 Mt of fine debris thus discarded could have been used for manufacture of cement (Valdiya, 1987 pp. 151). Damage to land and land-use was so serious that the people around filed a case to the Honorable Supreme court against the activity; and the Honorable Supreme court found the situation fit to stop the mining. Reclamation of mined area on slopes more than 14^o is rarely successful (Coates 1981), while in Mussoorie mining was being conducted on slopes of 30^o-50^o . This indiscriminate mining induced serious landslides and aggravated erosion. The debris produced in the construction of roads required for mining was from about 250 km for Mussoorie mines (Negi 1982).

About 14 ha of forested hill slopes above the village Khirakot in the Kosi valley of Almora district and several hundred hectares of the Hiunpani forest in the Chandak area and elsewhere in Pithoragarh district in Kumaun were being haphazardly and crudely mined for soapstone and magnesite respectively. (Valdiya, 1987). More than 4820 ha of land area in Kumaun Himalaya, 1147 ha in the Darjiling Hills, 438 ha in Himachal Pradesh and 886 ha in Jammu-Kashmir (Negi 1982) had been ravaged or very seriously affected by mining. In Sikkim mining of foliated and jointed phyllites for uraniferous polymetallic sulphides created landslides and aggravated erosion.

Impact of area strip mining on land

The best example of minimum depth of excavation, yet causing serious damage to land is associated with manufacture of bricks. Brick-kilns are very common in eastern India, in the Indo-gangetic alluvial plain. The industry is completely dependent upon a very fine variety of clay which forms a part of topsoil. The industry involves scraping out a layer of topsoil, mixing that with suitable percentage of water, putting that into moulds, then drying and backing these. The topsoil of huge amount is thus used-up by this industry. This top soil is a very precious natural resource, a very important part of lithosphere that takes part in ecosystem. It takes years to form a of topsoil by natural process. Loss such of a rare and important component topsoil damages greenery growing and greenery supporting potentiality of the region and gradually forces it to be turned to a degraded land.

Indiscriminate mining since 1961 had destroyed 50,000 ha of forest in Goa (Dsouza, 1984). Against the export of 12 tm/yr of high-grade iron ores 30 Mt of iron ore rejects were being scattered indiscriminately over 10,000 ha of paddy and coconut groves, thus diminishing the fertility of the soil and land. The washing of mineral ores for beneficiation had caused serious water pollution in the rivers as well as in wells and springs. Use of such polluted water is a source to land damage.

A study conducted in Kentucky (USA) revealed that the rate of erosion in a strip-mined area was 27,000 t/km^2 as compared to only 27t/km^2 in the undisturbed hill slope (Tank, 1973).

In La Utica county, Illinois the rate of ground loss due to mining is 29,33 m/yr. (High, 1982).

Impact of UG Mining on land

Many valuable minerals including some metals like gold, building stone, diamond, slither, salt, potash etc are mined through UG mining, such mining requires lesser amount of excavation to reach the deposit and may be some additional excavation that forms some dump of gangue mineral or tailing. However land damage created by these are less in comparison to those caused by OC. mining main land damage by of UG mining is mainfest if there is subsidence.

In case of GW withdrawal it is apparent that safe yield cannot exceed the long-time mean annual water supply to the basin. Withdrawals exceeding this supply must come from storage within the aquifer. Such permanent depletion is often referred as “GW mining” in analogy to mining of minerals, because as, a mineral once mined cannot get re-generated, just similarly withdrawal of water if caused up to this extent, the open space created in the aquifer cannot be recharged again if the aquifer compaction is manifested above as subsidence (as detailed in section 5). Large scale withdrawal of GW from Kolkata and Howrah cities had resulted in the sharp decline of piezometric level in the areas which is inviting hazards of land subsidence. The estimated amount of subsidence ranges from 3.33 m/y to 13.78 m/y. Though clearly visible evidences of land subsidence was not recorded, it has been suggested that these might spell danger in the future owing to continuous overpumping of the aquifer (Sikdar et.al.1996).

Impact of OC & UG mining combined

Decrease of green cover over mining areas is a known fact. To report a few among the studies conducted in the line mention may be made of Jharia coalfield (Ghosh, 1989), Raniganj coalfield (Chatterjee & Ghosh, 1994), Singrauli coalfield (Sekhar, 1996), Makum coalfield (Dutta 1997). Each of these studies have revealed that forest cover has depleted in these coal mining areas. This is happening inspite of a country-wide attempt, including the coal mining sector, to increase forest cover of India.

An attempt to search out the causes behind this makes one to recall the views of Sharma (1982) and Banerjee (1982). Sharma (op.cit) reported that India is loosing on an average 600 million tonnes of topsoil/year. According to some estimates made by the Ministry of Agriculture in March, 1980, out of India’s total land area as much as 175M hectares (ha) are subject to environmental problems, the situation is fast deteriorating, over 150 Mha of land are subject to serious water and wind erosion. Banerjee (op.cit) mentioned that in case of opencast (OC) coal mining the actual land-area damaged is 10 to 20 times the area directly used for mining. To list the causes of this, he mentioned about siltation in streams and ponds, disfiguring of water table, high velocity runoff and withering of vegetations as the only few. It is very obvious that afforestation activity on these lands can't give good survival or growth unless special care is made to make up the damage and restore land quality.

To view towards damage to water resources in mining areas, it is an established fact that mining damages surface and ground water resources. To report a few among the studies conducted in the line, mention may be made about the studies of Ghosh (1993) and Chatterjee & Ghosh (1993). Through such studies it was revealed (Ghosh op.cit) that in Jharia coalfield the relative heights of ground water level at different points were so different at close intervals that the water table appeared to be too uneven to be possible in a sedimentary terrain (Ghosh op.cit.). Otherwise, it can be told that no specific plane representing the water table could be searched out in the area. Another study in Raniganj coalfield (Chatterjee & Ghosh,op.cit) revealed that in the period between 1965 to 1985 the region was suffering a lowering of water table on an average @ 2mm/y. That the situation is deteriorating even after that, is proved by the fact that some parts of Raniganj coalfield are declared drought-prone areas, and suffer from severe water scarcity in every summer. Further, according to Ruthermund et al (1980) the Jharia coalfield, 100 years ago, was mainly a forest-cum-agricultural land, but now it will be difficult for any one to search out any real forest in this field. This is because the afforestation activity conducted here has not been effective, in all probability due to non-availability of topsoil and water.

An analysis of the mining and reclamation activities in coalfields revels that, as coal occurs in close association with sandstone and shale, which occasionally contains aquifer, whenever the aquifer occurs above the coal seam it gets excavated out together with the overburden (OB). When coal exploitation starts, water from the remaining parts of the aquifer flows continuously into the excavation site and requires continuous pumping out to facilitate mining. This creates firstly a cone of depression in the water table (WT) and gradually a regional lowering of WT. These effects have been identified in Ghosh (1993) and Chatterjee & Ghosh (1993).

These quarries while attempted to reclaim, is generally filled-up by materials from OB dumps, which are large pieces of sandstone and shale with high percentage of interspaces. These backfilled quarries when attempted to green, topsoil and water are applied on these. A major part of these topsoil and water goes down rapidly, through the interspaces of the filling material, to the base of the quarry, far beyond the reach of the roots of newly planted saplings on the land.

The excavated out aquifer is lost for ever because the impermeable layer below the aquifer, that was holding the water in the aquifer in undisturbed condition, is never regenerated. The cumulative effect of all these have been studied in Jharia coalfield as has been reflected in its land-use change through a period between 1925 to 1993 (Ghosh 2000a).

It is a time to think twice whether such loss of topsoil and water to deep underground (and hence loss of land quality are really assessed in the EIAs conducted. Whatever hydrogeological modeling, or water-budget analysis or even hydrogeological studies are conducted sometimes to supplement EIA, does it ever record such loss of aquifer? Even if the realization ever comes into the assessors' mind, does any EMP take up any activity plan to regenerate the excavated out aquifer? Answer to the last one is surely 'no'. How then one should expect the afforestation to be a successful programme?

The afforestation job is generally given to forest department. Mining companies spend for the purpose @ of about Rs 3.00 Lakhs/ha for getting the land green with saplings upto certain height, upto certain survival rate, upto certain number of years. After their responsibility is over, it is considered that the plants will survive on their own. The fact is, for such plantation topsoil is taken from somewhere else, thus it grows greenery at one place at the cost of greenery growing potentiality at some other place from where the topsoil is taken. And after the forest department withdraws the responsibility, the plants start withering because of not getting sufficient topsoil and water at the root zone. A major part of topsoil that was used for plantation has, by this time, gone down to the base of the backfilled quarry. Thus topsoil is lost once by getting mixed with subsoil and OB during excavation and again by going down to quarry base through open spaces of the filling material. It is not unknown to any environmentalist or an ecologist how worthy this topsoil is, what a long time is required for its generation through natural process, and hence how serious is its cost and how intangible it is.

3.6 Summary

Environmental impacts of mining on land and land environment may be summarised as follows under two items i.e. land quality and land use potential (Modified from Sengupta, 1993).

SPECIAL ATTREBUTE CATEGORY	**UNCONTROLLABLE CAUSAL IMPACTS**	**CONTOLLABLE CAUSAL FACTORS**
1. LAND QUALITY		
a. Surface texture	Rocks and spoils are put on surface	Characteristics of i. OB ii. spoil
b. Appearance	Appearance changed	i. Natural topography ii. Natural vegetation
2. LAND USE POTENTIAL		
a. Topography	Topography becomes more rugged	i. Natural topography ii. Bulking factor of OB iii. Mode of occurrence of the deposit.
b. Drainage	Disruption of natural drainage	i. Natural drainage pattern ii. Chemistry of OB iii. Precipitation
c. Vegetation	Removal of vegetation	i. Natural land cover pattern ii. Native vegetation

The environmental impacts of mining with respect to land and water resources can be listed as in Table

The most serious problem is that all the impacts on water and land resources work in a consorted manner to degrade the land and push the total region towards desertification. The matter has been explained through "land degradation cycle" (Ghosh 2000b) in fig. 1a, which works in accelerated speed in mining areas as has been expressed in figure 1b (Ghosh & Rani, 1999). The effects are cumulative, and the cycle runs on and on through innumerable internally connected loops so long it is not stopped forcefully by any strong care. This emphasizes the need of managing these intangible environmental impacts of mining.

Some more analysis of impact of mining on land and LU has been given in chapter VII while discussing economic viability of suggested LUMPs.

Table : Impacts of mining on land and water regime

A. Damage to water resources

Nature of damage	Nature of impact
I. Loss of surface water bodies by getting	
• excavated out	Tangible
• filled-up by rolling of OB materials	Only partially tangible
• silted by eroded materials from the land made devoid of green cover	Intangible
• infiltrated through subsidence crocks	Only partially tangible
• evaporated due to high temperature in fire areas	Only partially tangible
• evaporated due to higher temperature generated because of loss of greenery	Intangible
II. Damage to ground water resources by	
• lowering of WT due to pumping out of groundwater flowing at the excavation site and discharging it creating more of runoff and less of recharge	Tangible but rarely cared
• lowering of WT due to aggravated evaporation, loss of greenery and erosion	Intangible
• loss of aquifer due to getting excavated out	Intangible
• loss of aquifer due to getting compressed due to not having pore water pressure support for long time in the zones having lowered water table	Intangible

B. Damage to land

Nature of damage	Nature of impact
I. Loss of topsoil due to getting	
• mixed with subsoil and OB material during excavation	Tangible but rarely cared
• transported from open place to other	Intangible
• down to quarry base through the interspaces of materials backfilling the quarries	Intangible
II. damage to greenery due to loss at	
• core zone by felling and land excavation	Tangible
• core zone by OB dumping	Tangible
• buffer zone by shifting of habitation etc.	Tangible
• buffer zone by damage to land quality by getting covered with solid and water of adverse composition	Intangible
• reclaimed lands and some parts of buffer zones due to non-availability of water at root zone and for irrigation	Intangible
III. loss of energy, effort and cost spent	
• lowly effective activities for greening such partially degraded lands	Partially intangible
IV. loss of revenue that could be earned	
• from the land if reclaimed properly	Intangible
• by selling the land if reclaimed properly	Intangible