3. The Indian Scenario

3.0 Introduction

Land is the solid cover of the earth. It is a non-renewable finite natural resource to be used by human beings for all its purposes, essentials and extras of life. Land provides human race space to grow food, to construct buildings for living, setting industries, educational medical recreational and all other facilities. The users of land are growing at a rate of about 2% per year. New additions of land, if any, in the form of delta or by addition of meteorites can in no way be considered to be commensurate with the population growth. Thus land is already a scarce resource, and is getting more scarce day by day. The problem is more severe in India which holds more than 16% of global population in only 2.3% of global land area. Here per capita availability of usable land is even less than 0.3 ha. Hence, more and more land, which were previously not under human use, are being used for human purposes. This is disturbing the natural ecosystem and hence the other environmental attributes on which depends the existence and well being of human community.

3.1 Legal provisions

Greenery has got the potentiality to safequard or improve the quality of land and almost all other environmental attributes. Men has learnt this and hence realised the requirement of keeping green cover on a large portion of land.

The first official record of realisation in India about the need for preserving forest cover is the country's National Forest Policy of 1894. The policy had the following broad objectives:

1. The basic objective for maintaining forest cover was to preserve climatic and physical conditions of the country.
2. Other objectives were for supplying valuable timber for commercial purposes, fulfilling the forest based needs of the local people and for providing pasture land.
3. As per the statement, permanent cultivation received precedence over forestry.

Presently considered important issues like forestry research and training, forest conservation, wildlife management, catchment management etc. did not find place in the policy statement.

National forest policy, 1952

With the attainment of independence, priorities of National Government also needed revision to fulfil the aspiration of people in changed context. This included revision of Forest Policy. With this in view, GoI constituted Central Board of Forestry (CBF) in 1950. The first National Forest Policy for Independent India, formulated by CBF was announced in 1952. The policy laid down the following broad objectives.

i. Classification of forests according to their primary functions.

ii. Forests are valuable both in the physical field such as prevention of soil erosion, conservation of moisture and in the economic field of development of agriculture, industry and communication.

iii. Regularization of uncontrolled and excessive grazing to ward off its ill effects on the forests.

iv. Evaluation of a system of balanced and complementary land use to produce the most and deterioration the least.

v. Discourage extention of arable land from the forests.

vi. Cover one-third of total geographical area with forests, 60 percent in hilly regions and 20 percent in the plairs.

vii. Functional classification of forest viz. “Protection Forest”, “National Forests” and “Village Forests”.

Forest Conservation and Protection activities during the successive five year development plans were drawn in line with the new forest policy. Activities which received attention during subsequent five year plans are listed below:

Second five year plan

- Economic plantation on forest lands including plantation of commercially and industrially valuable species.
- Construction of forest roads.
- Establishment of wild life sanctuaries.

Third five year plan

- Large scale plantation of first growing species to attain self sufficiency in industrial timbers, fuel wood and other forest products.

Fourth five year plan

The forestry sector was planned with following objectives:

- Increase the productivity of the forests
- Link up forest development with forest-based industries.
- Develop forests as a support to rural economy.

Fifth five year plan

- Creation of large scale man made forests.
- Improvement of degraded forests.
- Development of farm forestry.
- Development of National Park, Launching of Project Tiger.

Sixth five year plan.

- Major thrust was on saving natural forests

Seventh five year plan

The seventh plan envisaged "Forests for survival" as its theme as regards to forest management. The plan gave highest priority to restore the forest cover on 33% of the geographical area of the country bringing under forests from existing level of 23%.

It was observed that inspite of the National Forest Policy of 1952 indicating clearly about "keeping one third of the total land area under forest", extensive diversion of forest land for non-forest purposes took place over the years. It could be inferred from the available information that the total forest area diverted for non-forest purposes between 1952 and 1980 was 4.5 million ha, i.e. at a rate of 0.15 million ha per year. In order to abate such diversion, the constitution was amended in 1976 (Forty Second Amendment) which inscribed "forests" under a new item 17A in the concerned list of the Seventh Schedule to the constitution. Following this was the Forty second Constitution Amendment Act of 1976 which introduced Article 48A for protection and improvement of environment and safeguarding of forests and wildlife. This was followed by the UN Conference on human environment, held at stockholm on 5th June, 1972. Subsequently the Forest (Conservation) Act was enacted in 1980 as a long felt measure to protect and conserve forests. The current rate of diversion of forest for non-forestry purposes is about 20,000 ha/annum (Anon, 2001, pp. IV-3).

The Environment Protection Act 1986 defines “environment” to include water, air, land and interrelationship between these and human beings, other living creatures, plants micro-organisms and property. This records the importance of land and the green cover on land. The Central Government is empowered by the act to frame rules for environmental protection.

The National Forest Policy, 1988, set by the GoI, MoEF, New Delhi mentions that the National goal should be to have a minimum of one-third of the total land area of the country under forest or tree cover. In the hills and in mountainous regions, the aim should be to maintain two-third of the area under such cover in order to prevent erosion and land degradation and to ensure the stability of the fragile eco-system.

In the World Environment day 1999 the Hon’ble Prime Ministry of India, Shri Atal Behari Bajpayee reiterated certain policy initiatives, in which the first one was a strategy to achieve 33% forest cover in the country.

In the Indian Constitution the citizens have direct access to the Hon’ble Supreme Court to ventilate environmental grievances as they are now deemed to be fundamental rights violations. Probably the best example for this in the field of mining is the case of limestone mining in Doon valley where mining on hill slopes was disturbing the surrounding LU so seriously that the people around had lodged a complain to the Hon’ble Supreme Court, and could get stay-order.

3.2 Land degradation in India

Tropical soils are surprisingly fragile and vulnerable to ruination. Nutrients in tropical soils occur mostly in the plants; the soil offers only the mechanical support for growth. When the canopy protection is demolished, soil temperature is raised to destructive proportions which hasten biological and chemical deterioration of the remaining organic matter. Heavy rains leach away the remaining nutrients and remove these by surface erosion of the productive upper soil horizon causing land degradation. India being in tropical zone gets seriously effected by this process.

Materials disintegrated by weathering and erosion are carried by running water. Some studies (Agarwal & Narain, 1991) revealed that in terms of sediment load carried by rivers, among the top five rivers of the world, three are those which passes through India. As per some scientists of UNEP (Mohanty, 2001) 2/3rd of world’s sediment transport to oceans is from southeast Asia.

Sedimentation rates in irrigation cannels and dams of India are now four to five times more than originally calculated by the designers (Valdiya, 1987). The forests at the foot hills at the banks of the rivers Indus and Ganges that were formerly inhibiting heavy run-off are now mostly lost.

More than 40% of land in India is seriously affected by erosion of one kind or other. The Indian rivers together carry to the seas annually about 1500 million ton of eroded material produced at the rate of 4.5 t/ha/yr., compared to the global amount of 24000 million ton removed from the vulnerable parts of the earth at the rate of 3'6 cm/1000 years. Erosion has become critical and pronounced in areas where man has indiscriminately used the land and tampered with natural balance by reshaping, modifying and defacing the topography, chiefs of some such activities being mining and deforestation due to related activities particularly on hillsides where the geodynamic conditions don't accept such disturbance.

It had been reported (Coates, 1981, pp.506) that 75% of Indias forest was lost in past 20 years, some parts of Nepal was having not even sufficient timber to cremate the dead bodies. Large tracts of Nepal had only 3 cm of topsoil.

As a result of such accelerated erosion the country is loosing valuable land at a rate of 5 to 7 million ha per yr. (Valdiya, 1987, pp.175). Reservoirs created for the purpose of electricity generation and irrigation are being filled so rapidly that their lives have been reduced by 1/4 th or 1/5th of the original. The deposition of sediments in the river beds has reduced their carrying capacity leading to overflow and recurring floods, that now spread over vaste and vaster areas.

The process of land degradation is intricately connected with desertification. About 5.7% of Indian landmass is a desert or desertic and quite a large part (one-third of the geographic area encompassing 76 districts) is cronically drought prone of which 13% area is on the brink of total desertification (Valdiya, op.cit.).

Inspite of the fact that the National Forest Policy of India states the requirement of 33% land under forest or green cover, India's average forest cover amounts to about 20% (considering the different sources of information). This indicates that India is far behind the targ*et* There are some mining areas in India (MAs) (e.g. Jharia coalfield) with even less than 3% land under forest cover (Ghosh, *et al.,* 1997). Further some studies on coal mining areas of India (CMAs) have revealed that rate of dwindling of forest cover is significant (Ghosh & Rani 1999). These reveal the fact that decrease in forest cover is a characteristic feature of MAs.

Some UNEP information (Mohanty, 2001) states that the Asia Pacific is suffering deforestation @1.6% /year. The problem is getting aggravated inspite of a country-wide green revolution since 1980s, with a special attempt to generate green cover in MAs. This indicates the existence of some unidentified factor(s) opposing all the efforts to green the mining degraded lands. These factor(s) must be much powerful than the efforts being put by the country, including the mining companies, forest departments and all others working to increase the forest cover. It appears that the prime requirement is to identify the basic cause(s) of persistency of the problem (decreasing green cover in the mining areas) inspite of the countrywide effort, and then to up-root the cause (working as lacuna). This calls for an efficient LUPg system to manage the observed problem, i.e. for preparing a LUMP for at least the MAs.

3.3 Damage to land and land-use by mining

3.3.1 General effects

The human activities which are instrumental in creating land degradation are mainly deforestation, cultivation, grazing (specially over-grazing), excavation for 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 3.1, after Ghosh, 2000b, pp.272) 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.

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 and 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 LUs are disturbed and so the sources of income of the people are also 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.

3.3.2 Damage by different activities for 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.

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 or three crops every year (one rain fed and the others 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 to compensate the soil moisture deficiency 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), which will thus increase turbidity and siltation of surface water bodies resulting to 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 due to loss of capilary water through this surface lowered due to erosion. 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 Fig. 3.2 (after Ghosh 2002).

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.

Clearing the vegetation cover

Mining needs clearing the acquired land which in most cases need removing its green cover, or even deforestation in some cases, which invites land degradation as detailed in Fig. 3.1 and 3.2. Among the odd activities required for mining, the most prominent, effective, inevitable activity is, while its long-term effects, i.e. damage to greenery land degradation and desertification are indirect, and hence, to some extent intangible, these produce most serious effect on land. Utilities of greenery in preventing land degradation has been detailed in section 3.3.4.

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 ore mines in Western Ghat region of Karnataka, Noamundi iron ore mines in Bihar, Jhamarkotra phosphorite mine in Udaipur, Rajasthan, many coal quarries in Raniganj coalfield (RCF) and Jharia coal field (JCF) 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 (OB) (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 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 looses its soil cover and 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 site. 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 (Fig. 3.1 & 3.2).

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 requires continuous pumping out of water from that site to facilitate mining. Land degradation due to this has been detailed later in the same section under the heading “pumping out of mine water”.

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 for the purpose of physical reclamation, it is filled with a material too loose to represent the impermeable layer that was originally existing at the base of the aquifer. Thus the aquifer is never regenerated (Fig. 3.3). This creates a situation which goes against sustainable greenery growth over these mining degraded lands, even after so-called biological reclamation. The matter has been detailed in section 3.4.4.

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. 3.1 & 3.2.
- 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 to reach the mining site 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, lead-zinc 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., oil, 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.

Effect of excavation on water resource

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.

Overburden (or solid waste) dumping

Amount of OB (or gangue) 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 or spoil (SP) 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 LUs there by hurting these by big pieces of OB/SP, 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/SP 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 from 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 Fig. 3.1 & 3.2. The land which receives eroded and washed fines, gets covered by these, which also damage the land's infiltration potentiality and greenery growing potentiality.

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. 3.4). This may ultimately result regional lowering of WT and aggravate the process of land degradation through a process detailed in Fig. 3.2. The matter of lowering of WT has been detailed in section 3.4.4.
- ➢ 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 regional 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.

Haulage, storage & transportation

Excavation is followed by haulage, storage and transpiration of excavated materials. All these activities spread dust and thus 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.

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. Seriousness of the matter may be reaslised from the following facts :

- As per Valdiya (1987, pp.149) by A.D. 2000 India will be mining annually 7 Mt of copper ores. The yearly production of tailings will amount to 36,50,000 m^3 or nearly 40 million 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 0.5 ton of red mud (Sharma, 1982). It has been estimated by some environmental geologists that, by 2000 AD India will produce 10 million 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 in Western ghats region more than 13 million ton of dominantly siliceous tailings are produced per year (Valdiya, op.cit.).
- At lead-zinc mines the spoils produced are highly toxic, particularly if the metal content is more than 1,000 ppm.
- If water gets polluted, it is able enough to create degradation of land on which it is applied. 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 districts MP. More than 12 million ton of ore fines had accumulated here in a time span of ten years, 1977 to 1987 (Valdiya, op.cit.). 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, 1982.
- ➢ 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.
- ➢ 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.

The best management of such wastes is to use-up those for any purpose suitable to its physical and chemical character. An example of management of such waste can be obtained from a very old case detailed next.

- ➢ 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 huge tailings piles, until after world war II when new uses of titanium in paints were discovered, so that the old tailings were reworked for ilmenite and partially used up. (Coates 1981, pp. 20)

Some other uses may be as road material, filling material (as detailed in chapter 5, for aquifer regeneration), or in ripraps or gabion cages (Valdiya, op.cit.) for erosion control on slopes, or even for landscaping for beautification of a land depending upon the physical and chemical characters of the waste.

3.3.3. Subsidence due to mining

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 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.

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 remove the fine pores which were providing spaces in the strata produced by removal of water due to lowering of WT, thus to compensate the loss of hydrostatic pressure. Under such circumstances 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.

Similar situations may occur also due to withdrawal of petroleum from the pore space of the reservoir rock. Examples of subsidence due to such fact are common world over. Mention may be made of San Joaquin Valley, California, the world’s largest subsidence area effecting a land area of 13500 sq km, through an average lowering of 1m, the maximum amount of lowering being 10m (Coates, 1981).

Subsidence due to GW withdrawal has been predicted at Kolkata by a group of Scientists (Sikdar, *et al.*, 1996).

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.

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.

3.3.4 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 the previous sections, 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 (Fig. 3.1 & 3.2) already explained. These are continuous cycles, which continue to work in repetitive manner so long not stopped by some strongly effective action, and thus push the land towards desertification.

It is hence 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 preventing land degradation 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 evaporanspiration 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 run-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 the deleterious influences on land that are created by damage to greenery 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) has been detailed in section 2.3. the extent of land degradation in India has been detailed in section 3.2. 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 are more prominent in catastrophic storms in hilly terrains is proved by the set of data (Ives & Messerli 1989) which states that the rate of erosion in

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

The seriousness of erosion rate in India is clear from the fact that if the annual sediment transport of top five rivers of the world are compared, the three rivers in the list are those which pass through India. This is revealed from table 3.1.

Table 3.1: Sediment load of top five rivers of the world (c.f. Holeman, 1968)

River name	Location	Sediment load (million t/yr)
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 (Agarwal & Narain 1991) that out of the total annual 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 land 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. The demand of the situation is that already the amount of damage caused is colossal, a single drop should not be added to this ocean of damage.

3.4 Case studies

3.4.1 cases of contour strip mining

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 and associated rock or lowgrade ore 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 north-west 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 million ton 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 Hon'ble Supreme Court against the activity; and the Hon'ble 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, op.cit.). 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, op.cit.) 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.

3.4.2 Cases of area strip mining

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 consumed by this industry. This top soil is a very precious natural resource, a very important part of lithosphere that takes a major role in proper functioning of the ecosystem. It takes several years to form a cm of topsoil by natural process. Loss of such 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 (J. D. Souza, 1984). Against the export of 12 million t/yr of high-grade iron ores 30 million ton 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. Washing of the 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 cause of 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).

3.4.3 Cases of UG Mining

Many valuable minerals including some metals like gold, building stone, diamond, 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 conducted 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 3.3.3). Large scale withdrawal of GW from Kolkata and Howrah cities had resulted in 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 per yr to 13.78 m per yr. 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).

3.4.4 Cases 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 the 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 per year. According to some estimates made by the Ministry of Agriculture in March, 1980, out of India’s total land area, as much as 175 million ha are subject to environmental problems, the situation is fast deteriorating, further over 150 million ha of land are subject to serious water and wind erosion. Banerjee (op.cit) mentioned that in case of 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 per yr. 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 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 (Fig. 3.3). 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, these never record such loss of aquifer. Even if the realization ever comes into the assessors' mind, any EMP does not take up any activity plan to regenerate the excavated out aquifer. Hence, there remains very remote chance that afforestation on such lands will 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. Further, 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 is the loss.

A detailed study on LU of JCF through a time span from 1925 to 1996 has been provided in the previous monograph of this series (Ghosh 1999a). The total finding is that the LUP in the field in going on suffering serious changes. Damage was maximum by the mining under private sector. Some benevolent approach was there after nationalisation of the coal mining industry in India. It shows some indication of increase in the amount of green cover in 1980s. However, implementation of Land Use Management Plans (LUMPs) could not be made notably effective due to some cause or other (detailed in chapter 4 and 5 of this monograph). Further, nothing could be commented on the matter firmly because of several facts. The most notable one was

- non availability of systematic data and
- not following any definite LUPg procedure.

LU data had been generated wherever and whenever required; and LU classes have been decided differently in different cases based upon the requirement e.g. in some cases it is reported that fire protection was done over this-much amount of land, or this-much amount of land was greened. No systematic dependable data is available to know really how much land could sustain that green cover upto what extent of time generating what percent of green cover. Some similar comments have been made by scientists working on LU over the globe, as has been detailed in chapter 2. Hence demand of the situation in MAs is

- to decide some definite LULC classes, under which data will be collected from MAs
- to collect and report data on some regular intervals so that it can be used for the purpose of monitoring.

3.5 Summary

Environmental impacts of mining on land and land environment may be summarised as in table 3.2 under two items i.e. land quality and land use potential (Modified from Sengupta, 1993).

Table 3.2: Impact of mining on land quality and LU potential

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 LC pattern ii. Native vegetation

The environmental impacts of mining with respect to land and water resources can be listed as in Table 3.3A and 3.3B.

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. 3a, which works in accelerated speed in mining areas as has been expressed in Fig. 3b (Ghosh, 2002). 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 3.3: 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 cracks	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 one 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 fine 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 for	
• 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