7. Guidelines for land use planning in MAs

7.0 Introduction

Land forms such an important component of environment that if its quality is protected properly, it can help protecting the quality of all other aspects of environment, Fig. 7.1. At the time of creation of the earth the nature had put the land-water forest ecosystem in a balanced juxtaposition. Any alteration of it results to an equal and opposite reaction within the same system. Such reactions may effect the mankind, a part of the same ecosystem, and may not be very comfortable to it. Hence any activity which disturbs this balance should be conducted with special care so that this balance is minimum disturbed.

The above referred system is composed of four spheres the lithosphere, hydrosphere, biosphere and atmosphere. The first three together form the ecosystem. Mining, though a developmental activity, is bound to damage this balanced ecosystem by disturbing greeneries, land and water resources, thus the land's usability and LUP of the concerned region gets altered very prominently.

It is very much required that these damages are repaired and the concerned lands are reclaimed at the earliest, because the effects of damage to land are cumulative. The matter is very serious in Indian condition because mining started here long back in nineteenth century. When the need of environmental protection was beyond realisation, and even now the proper technology to repair the damages has not been developed in some aspects.

7.1 Land use planning in India

The above situation calls for an appropriate LUPg system for India. The National organisation working best for LUPg in India is the National Bureau of Soil Survey & Land Use Planning (NBSS-LUP). It has been explained in chapter 4 that the system followed there is difficult to use for MAs. This calls for a proper LUMP system suitable for MAs of India.

India's forest cover was only 14.1% in 1983 (Valdiya 1987, pp.31). since 1980s a country-wide attempt is being undertaken to increase green cover. On World Environment Day 1999 the Hon'ble Prime Minister of India stated some policy initiatives, of which the first point was to have a strategy to achieve 33% forest cover in the country. This calls for prevention of encroachment of forest covered lands for nonforest use. Even after this some UNEP scientist has observed (Mohanty, 2001) that the Asia

Pacific region is loosing forest cover by 1.6% per year. Some research activities have identified that green cover over some MAs in India is going on decreasing. This fact that the amount of forest cover over India is going on decreasing is definitely an alarming fact. It is imperative thus that the root cause of the problem is searched out and eliminated.

The problem has been emphasised by detailing the LU scenario of India and the impact of mining on land and LU. The LUPg system followed in US etc., and also in India has been detailed, limitations for using the existing system for MAs have been stated and LUPg system and LUMP for MAs have been suggested finally. The requirement now is to provide some guidelines for LUPg for MAs which can be generated based on determinants of LUP.

7.2 Problems of land-use planning in India

Need of environmental protection was realised in the second half of 20th century, which was officially recorded in the Stockholm Conference on 5th June, 1972, the first "World Environment Day", but even now, in the 3rd year of 21st century the situation has not improved much. It has been a matter of concern because if the activities run similarly even in this century, the future generations may encounter with an unhabitable earth.

Among the above referred yet untackled aspects, a very important one is LUPg. India doesn't have any technology of its own for LUPg for MAs. It has been emphasised by scientists working in the line that there cannot be any universal LU rule (Rhind & Hudson, 1980). Whatever technologies India is using, are borrowed technologies, and donot take care of mining degraded lands. Moreover, whatever post-mining land-use planning activities are undertaken for MAs are not fitting properly to the requirements. This is proved by the situation that inspite of the country's National policy of developing 33% forest cover, and inspite of a country-wide attempt since 1980s to grow more green cover over the country including the MAs, India is far behind the target.

Further, for mining areas, it has been made mandatory by the GoI that, before starting any mining project the mining company should submit and get approved by the MoEF an EMP for the project, of which LUMP forms an integral part. Even after this it is being noted that the forest cover in MAs is going on decreasing. The cause behind this may be that the LUMP submitted in the EMPs are being possible to be implemented properly in some limited cases only, and even where implemented, the ultimate result in the long run is not at par with the requirement, due to some cause or other. Further, there may be some unidentified and hence uncared controlling factor(s), not allowing the desired green cover to develop.

Seriousness of the above discussed matter may be realised from the following facts:

- Damage to green cover initiates the “cycle of land deterioration” and the effects are cumulative (Ghosh 2000b).
- One full-grow tree is capable of cooling its surroundings equal to five(5) average air conditioners operating twenty (20) hours a day, about 93 m^2 of woodland can reduce the noise level by 8 decibels, and one hectare (1 ha) of forest is capable of absorbing carbondioxide and fumes generated by twenty (20) cars (Coates, 1981 pp. 512).
- Rainfall in the Amazon basin in South America is stimulated by dense forests in that region (Allen, 1980).
- Forest clearance doubtless causes perceptible decline in precipitation (Valdiya, 1987). Observations in Jharia coalfield (Ghosh 1986) corroborates this.
- The problem is more severe in mining areas because mining and its related activities are bound to damage green cover. If adequate attention is not paid to regenerate these, the green cover over the region goes on decreasing.
- Such damages to green cover in CMAs is persistent inspite of the effort of the mining companies to green the mining degraded lands, and inspite of the special care taken by the MoEF, GoI to protect and increase forest/tree cover over the country, specially in the MAs.

7.3 To identify the cause behind the problems

Determinants of LULC and hence LULC pattern (LUP) are soil characteristics, climate and human interaction with land. Quality and quantity of such interaction is dependent upon quality and quantity of users of land, i.e. the population on and around a specific land, because the human activities like agriculture, forestry, deforestation, industry, energy production, settlement, recreation, water storage and its catchment alter the LUP of the area. The quality and quantity of such activities depend largely upon educational and financial level of the population in and around the land. Further, some such activities which are concerned with gaining mineral resources from the land (i.e. mining) depends upon availability of an economic and mineable mineral resource in the land, which is again a geologic and hence natural factor.

Thus a huge number of factors appear as determinants of LUP in an area. How these factors interact to produce different LUP in different environmental, social, geological and historical context had not been interpreted firmly. However, there were many theories (Spangale *et al.*, 1976) about relative magnitude of influence imposed by the different factors discussed above.

Hence to generate a set of LUPg guidelines for MAs it is required to identify the determinants of LUP change, to quantify the capacities of each of these determinants in influencing LUP change in MAs and hence to generate a strategic guideline to counter-act their capacities so that the LUP of the area suffers minimum change. This requires a statistical analysis of LUP change suffered by the MAs in the country. Realising the fact that it will be a seriously time taking job, an attempt has been made to conduct the study in a piece-meal manner, and it was started with coal mining areas of India (CMAs).

7.4 Identifying determinants of LU change in CMAs

7.4.1 Damage to LUP by coal mining in India

India documents a very long history of coal mining. The first attempt of coal mining in India dates back to 1774 (Gee, 1932) and the first consignment of 92.9 tonnes of coal was brought to Calcutta (presently Kolkata) from Raniganj in September, 1775. Indian coal was used in railways in 1855, when the section between Howrah and Raniganj covering a distance of about 260 km was opened. At that time Raniganj coalfield (RCF) was the only producer of coal in India and the production rate was very low. In 1857 the production was 50.5 tonnes. With the expansion of industries and railways, demand for coal went on increasing, and exploitation started in the other coalfields like Jharia, Ramgarh, Bokaro etc. and the coal production in India started increasing. The production from RCF was 217 tones per year in 1858 and 6000 tones per year in 1929-30 (Chakraborty & Singh, 1989).

The first mine fire and subsidence in Raniganj coalfield RCF was reported in 1864-65 (Prasad *et al.*, 1984) gradually such incidences also started increasing.

In these days the mining activities were being conducted by the private business houses and their method of working was completely unplanned. The idea of “environmental protection” or “land protection” did not exist in those days. Ultimate goal of these mine owners was to get coal, as much as possible, at minimum cost. This started producing degraded lands in the forms of fire areas, subsided areas, abandoned quarries, OB dumps and barren lands produced due to damage to water resources and spreading of OB materials.

Such selfish mining continued upto nationalisation of coal mining industry in India, in 1972-1973. Parallelly exists the official record of realisation of need of environmental protection; the milestone being the first “World Environment Day” celebration on 5th June 1972. But the need of land protection or land reclamation was realised much later.

Damage to LUP in CMAs as is observed to-day is the cumulative effect of all these since 18th century.

7.4.2 Case studies

Damage to LUP by mining has been detailed in chapter 3. It initiates immediately after land acquisition, when starts shifting of pre-mining LUs. This may require shifting of habitations to new sites, which may require damage to greenery at the new sites. Further, to compensate a cultivation land may require cutting some greeneries which were existing at the new site to be used for the purpose. Regarding forest-lands to be disturbed by mining "compensatory afforestation" is an oft-told activity but to view from the stand-point of ecology "no forest can be compensated in a year or two", as "forest is the sum total of ecological edaphic and biological parameters" (Dutta, 1989). What can be done is, only "compensatory plantation". Saplings of selected forestry species planted in the name of "compensatory afforestation" can only form, at best, a dense population of plants. This will take a considerable number of years to from a real forest, i.e. "a natural association of plants and animals" something like which existed in the pre-mining forest-ecosystem, i.e. something almost similar to that which was originally formed by the nature.

Over and above such direct damage to ecosystem after land acquisition, greeneries and surface water bodies may get damaged by direct excavation (at the quarry sites) and OB dumping (at the OB dumping sites) causing a direct damage to ecosystem.

Any excavation, be it at the mining site or at the site for rehabilitation of the population to be shifted, opens a source of severe erosion and hence damage to land and surface water bodies by siltation.

Excavation of OB materials needs forming OB dumps, which when get spread over the surrounding land, damage greenery over it. Further, to facilitate excavation below water table it needs pumping out of water which damages ground water resources of the region. This results into chances of damage to greenery.

After excavation the coal needs haulage, storage, transportation and beneficiation, after which it is used. Throughout the total process coal-dust gets spread over the surrounding lands and greeneries. This also damages greenery growth and specially sprouting of fresh leaves.

Damage to greenery results in more barren land, more erosion, loss of surface water bodies by siltation, hence decrease in irrigation potential in the region which triggers the cycle of land degradation as detailed through Fig. 3.1. (Ghosh, 2000b). This total process, once started in mining areas works through number of "do-loops" in accelerated speed resulting into more damage to greenery as detailed in Fig. 3.2 (Ghosh, 2002). The ultimate effect is damage to ecosystem which is exhibited in the region's LUP. Studies from JCF corroborates this fact (Ghosh 2000a). Similar findings have been obtained from RCF, (Chatterjee & Ghosh, 1994), Singrauli coalfield (Sekhar, 1996) East Bokaro coalfield (Das, 1996) and Makum coalfield (Dutta, 1997), as detailed next.

A study on RCF (Chatterjee & Ghosh, 1994) has recorded gradual and very prominent decrease of area under cultivation and natural vegetation in this field through the period between 1929 and 1989 and generation of culturable wasteland over more than 33% land area of this field. The data is given in the table 7.1

Table 7.1: Depletion of green cover recorded through 60 years in Raniganj coalfield

S. N.	Feature	1929	1974	1988
1.	Cultivation area (sq km)	213.07	161.26	46.05
2.	Percentage area under cultivation (%)	71.02	50.42	15.36
3.	Natural vegetation covered area (sq km)	12.81	10.15	15.13
4.	Percentage area under natural vegetation (%)	4.27	3.38	5.05
5.	Culturable waste land sq.km.	--	--	100.36
6.	Percentage area under culturable wasteland (%)	--	--	33.45

Source: Chatterjee & Ghosh, 1994

A study from East Bokaro coalfield of Bihar (Das, 1996) revealed the change in LUP the mining area experienced in the period between 1929 and 1985, as being detailed in the table 7.2.

Table 7.2: LUP in the East-Bokaro coalfield

LU/LC classes	Area covered in %		
	1929	1976	1985
Built-up land	4.95	13.02	17.11
Crop land	55.31	44.41	42.38
Fallow land	--	0.01	0.81
Forest land	31.76	27.82	16.74
Wasteland	2.28	7.80	15.54
Surface water bodies	5.70	6.94	7.42

Source Das, 1996

The table shows that through 56 years of mining the region has experienced a loss of about 15% of its forest cover which amounts to (8879.38 ha – 4659.48 ha) i.e. a loss of 4219.90 ha of forest cover in 56 years, i.e. about 75.4 ha per year in a single coalfield together with loss of some cropland.

A study from Rihand reservoir and its surroundings in Singrauli coalfield (Sekhar, 1996) reveals data on loss of green cover (agricultural land and forest cover) in the area within a span of 13 years between 1982 to 1995 as detailed in the table 7.3.

The table shows a prominent decrease of agricultural land and forest land. Moreover open forest and degraded forest has increased at the cost of dense forest. Some forest land has gone under agriculture; land amounting to 180 ha has grown forest outside the notified forest area while 2360 ha of forest cover has been lost within the time span of 13 years. Loss of 2180 ha in 13 years means loss of around 168 ha per year.

A study from Makum coalfield (Dutta, 1997) indicates serious loss of forest land and some cropland, as detailed in the table 7.4.

Table 7.3: Change in area coverage by LU/LC categories in Rihand reservoir & its environs

Sl. No.	LU/LC categories	Area in hectares		
		1982	1994/95	Changes
1.	Built-up land	840	3520	+2680
2.	Agricultural land	19190	14230	-4960
3.	Forest			
	Dense forest	15170	11540	-4630
	Open forest	1480	2630	+1150
	Degraded forest	3840	4950	+1110
4.	Water bodies	26080	27400	+1320
5.	Open lands, with or without scrub	8020	7540	-480
6.	Others			
	Quarries	900	1830	+930
	Mine dumps	620	1180	+560
	Agriculture within notified forest area	--	1140	+1140
	Dense forest outside notified forest area	60	240	+180

Source: Sekhar, 1996

Table 7.4: Change in LU/LC from 1965 to 1988 in MAKUM coalfield

Sl. No.	LU/LC categories	% land of total study area		
		1965	1988	Changes
1.	Cropland	14.43	9.23	-5.20
2.	Fallow land	15.67	10.71	-4.96
3.	Hutments with plantations	6.49	14.97	+8.48
4.	Built-up land	5.31	9.04	+3.73
5.	Dense forest	27.22	11.53	-15.69
6.	Open forest	4.02	6.91	+2.89
7.	Degraded forest	10.83	18.72	+7.89
8.	Quarry & mine dump	1.48	2.93	+1.45
9.	Tea garden	14.06	15.18	+1.12
10.	Waste land	0.49	0.78	+0.29

Source: Dutta, 1997

This indicates loss of 15.69 ha of dense forest in 23 years, i.e. about 0.7 ha per year. Apparently it may not be a serious rate but the fact is, this region is almost like a hilly region. It may be noted from the table that built-up land is very less here, only about 9%. Such regions should have 66% of land under forest cover as per the National Forest Policy of GoI, 1988. While in actuality dense forest cover was 11.53% in 1988 which is again going on decreasing. This explains seriousness of the situation.

A study in JCF detailed in a monograph (Ghosh, 1999b) and a book (Ghosh, 2000a) details the seriousness of the situation in JCF. A field of about 450 sq km land area originally a forest-cum-agricultural land (Ruthermond *et al.,* 1980) now rarely shows any effective forest cover.

7.4.3 Field data collection

Questionnaires were communicated to different CMAs with a request to fill-up these to get data on LUP in each individual CMAs for two different time levels, i.e. 1994 (a time after about 100 years of coal mining in India) and previous (as back as available) to know the condition of days nearest (as far as possible) to pre-mining days, in order to get data on LUP of the area before any disturbance and after disturbance through about 100 years (as far as possible).

Parallelly, information were collected on different natural and human/social characteristics of the respective areas which could have some control on LUP of the area. These are related to geology, topography, water availability, soil (quality and thickness), population (density and income) etc. over the region and also the life, depth, nature (opencast or underground) and area of mining.

Data could be made available from 31 CMAs.

7.4.4 Data processing and analysis

Attempt was made to deal with the data on LUP, as was received from CMAs. From the received information the land-cover/-use types, as could be visualised in different CMAs were grouped into six groups, namely forest-cover (F), cultivation lands (C), built-up areas (B), mining areas (M), water bodies (W) and others (O) to include barren lands, stony lands or any other not falling into any of the other five types mentioned.

These processed data were analysed to study whether the CMAs have suffered any change in the components of LUP through past years. The change was studied with reference to the above listed six components, which obviously varied from sample to sample.

As the sample size was more than 30, it was definitely a normally distributed sample. As per the standard concept of normally distributed population (Kreyszig, 1999) this sample was well suitable for statistical analysis of the population to reveal a reliable result. Thus from this data it could be possible to study the change in LUP if any, experienced by the CMAs in past years, and its significance.

The 31 samples available representing the population were first analysed individually to record the change experienced by each of the above referred components of LUP through the time span between the past days (for which the data could be made available) and 1994 (the actual time span covered varied from sample to sample). The observations for two randomly chosen samples have been presented pictorially in Figs. 7.2a and 7.2b. Field experience on the subject indicates that the quality and quantity of alterations may be different by OC-mining and UG-mining; this fact had also been given proper importance during assessment.

Analysis of the total population revealed that **forest cover** in CMAs went on decreasing through the period under consideration. Further, among the UG-mining areas only in one(1) case forest cover had increased and decreased in (fourteen) 14 cases. While among the OC-mining areas forest cover decreased in thirteen (13) cases, remained same in three (3) cases and increased in none. When studied mathematically, the overall change in forest cover was noted as -0.37 for 31 samples (/yr.).

Whenever mining is conducted in any area, the previous land-use gets disturbed and the area retains its use in **mining**. In the present case also the amount of land being used for mining went or increasing. However, among the 31 cases studied, the amount of land in mining use had been noted to experience slight decrease in 1 case of UG-mining and in only 1 case of OC-mining, no change in 9 cases of UG-mining and 4 cases of OC-mining while in other 16 cases it had increased. When calculated for the total population the change in the quantity of land being used for mining resulted to be 0.63 for 31 samples (/yr.).

Similarly the data for agricultural land, built-up land water bodies and others were processed and analysed.

7.4.5 Assessment of LUP change

As the next step of activity, changes (through time) in the amount of land area by the different components of LUP in CMAs were considered statistically with an attempt to find out the trend of change.

There are concepts and procedures of environmental impact assessment (EIA) of mining activities which takes into consideration all the visible and tangible effects. All land-use plans or land reclamation plans which are developed for mining areas, necessarily take care of the findings of such EIA. The present study revealed that there remains something beyond the scope of such EIA, hence plans based upon that suffers from some "lacuna". Hence, this study tried to account for all types of impacts of mining on LUP of CMAs and the surroundings by considering matters in a holistic manner to include the visible and invisible, direct and indirect, also tangible and intangible, short term and long-term impacts, upto 100 years or more in some cases. This followed from the fact that damage to land and LUP by mining and related activities are both short term and long term, not all visible, some are intangible but multiplies themselves through time as revealed by the land degradation cycle (Ghosh 2002) detailed in Fig. 3.2. Some such idea could be drawn to some extent from the comments of Banerjee (1982) as he explained that the area of influence of environmental disturbance by coal mining is more than 10 times the area directly damaged by mining.

In the above background the follow-up action of the research was planned with the basic purpose to assess the actual quantity of each LUP components altered to some other land-use in CMAs through time (the maximum span for which data could be made available in respective areas) and to establish the trend of change in LUP.

The summary of findings obtained may be listed as follows:

- Forest cover in these areas went on decreasing through time for both OC- and UG- mining areas; when studied mathematically, slope of the line representing the overall change (per year) in forest cover was -0.37 for 31 samples.
- Agricultural land in these areas went on decreasing through time, further when visualised for OC- and UG- mining areas separately, it was noted that the decrease is more prominent in OC- than in UG- mining areas. When calculated statistically, the overall change in amount of cultivation land (per year) came out to be -1.69 for 31 samples.
- Built-up lands in these areas went on increasing with time in general and for both OC- and UG- mining areas. When analysed critically, the overall change of built-up lands (per year) for 31 samples resulted to be 0.31.
- For water bodies and aquifers, mining is a damaging activity but if unfilled, the depressions created by mining may generate some surface water bodies; this was revealed by the fact that amount of

area covered by surface water bodies had suffered a very nominal change in most of the cases. Further, when calculated the overall change (per year) in land occupied by surface water bodies was 0.03 for 31 samples.

- The land-use recorded as "others" contains many components thus revealed varied facts. However, in general mining damages green cover and increases danga/barren-land. When studied critically, the overall change (per year) in this category of land-use amounted to 1.01 for 31 samples.
- While mining is the main activity causing the above changes in LUP, it is obvious that as mining proceeds, the amount of area under mining use increases. When calculated statistically, the overall change (per year) in amount of area under mining-use resulted to be 0.63 for 31 samples.

The very fact that the change in barren-land (others) was 1.01 which was more than that for mining (0.63) revels that mining related activities and the after-effects of mining create more amounts of barren-land than the amount of land directly disturbed by mining. This corroborates the ideas of “cycle of land degradation in MAs”, (Fig. 3.2).

The relative effect of mining on different land-use types can be expressed by the following relation.

LUP change due to units area mining

= (M) + Change in {(F) + (C) +(B) + (W) + (O)}

On substituting the actual results of study, the following expression was obtained

Change in LUP

= (M) - 0.60 (F) - 2.70 (C) + 0.50 (B) + 0.05 (W) + 1.75 (O) ……….(1)

(Rani & Ghosh 2001)

7.4.6 Significance of the changes

Among the 6 different components of LUP considered, the "forest cover" is the chief one that protects ecosystem, hence statistical significance of change in forest cover in CMAs was analysed with specific stress. Statistical analysis of the data and results revealed that forest cover over the concerned area had decreased through the period for which data could be made available. Also it was noted that the magnitude of decrease of forest cover with reference to time was statistically significant at 5% level of confidence (Saxena, 1981) as recorded (Ghosh & Rani, 1999).

Significance of mean change in LUP in CMAs per year as observed was calculated applying "*t*" test (with d.f. n-1) with the hypothesis that **in a hypothetically ideal eco-friendly condition change in LUP components should be "zero" (O)**. It was observed that change in case of (F), (C), (B) and (M) the hypothesis is getting rejected.

The above findings indicate that inspite of serious attempts to green the mining degraded lands through about two decades and inspite of MoEF's special vigilance on LUMP in CMAs, the LUP in CMAs are changing significantly with respect to (F), (C), (B) and (M). The matter is serious specially because (F) and (C) are going on decreasing and these changes are statistically significant.

Next was tested the significance of correlation coefficient between change in each LUP components and mining using 't' test with d.f. n-2 for the hypothesis that **the population correlation coefficient of LUP components with mining is "zero"**. The hypothesis was rejected in case of r(M)(F) only. This meant that the fact is, "as mining proceeds, forest cover in CMAs goes on decreasing and this decrease is statistically significant as per standard statistical tables" (Rani & Ghosh 2001). Definitely this does not indicate an eco-friendly change.

From the above fact it was realised that there is some unidentified and hence uncared (while formulating EMPs & LUMPs) factor(s) influencing the efforts of afforestation and biological land reclamation in CMAs.

Statistical analysis of the data reveals that as a result of coal-mining in India through time while land under mining use and built-up land has increased significantly, the green cover in the area, namely forest and agricultural lands have decreased. Specially the decrease of forest cover is significant. This is a serous damage to ecosystem. In this reference it may be recalled that according to the National Forest policy resolution of India of 1952 that forest area should be raised to 33%, (about 66% in the hill region and 20% in the planes), and India is already far behind the target.

Physical significance

If the equation 1 in section 7.4.5 be recalled, it states:

Change in LUP=(M) – 0.60(F) – 2.70(C) + 0.50(B) + 0.05(W) + 1.75(O). This indicates that per unit area of mining the region looses 0.60 units of forest cover and 2.70 units of cultivation land. Thus one unit area mining damages 3.30 (2.70+0.60) unit area of green cover. This is happening in spite of attempts to green the mining degraded lands. The points follow from this observation are:

- It is not only mining, many other ancillary activities and conditions are responsible for loss of green cover in mining areas.
- Attempts are being made to green the mining degraded lands only, while the additional 2.30 ha (3.30-1.00) that loose the green cover due to ancillary activities, which are the intangible impacts of mining, are not enjoying such care.
- Any land selected to grow green cover may not be capable to support it, as a land's capability to support green cover depends upon many other factors, other than land/soil suitability.

Some of the factors like surface water availability, topographic set-up, rainfall, nature and thickness of soil cover have direct control on land's capability to support green cover. There are some other factors which designate the degree of land-degradation caused, and hence in turn control the possibility of growing greenery on it. These are, excavation depth, extraction thickness, project area, life of the mine, characteristics of fault(s) (if present) in the area and strata dip. The third set of factors are those on which depends the degree of sincerity by which the actual (not planned) attempt will be made to green the lands in the region. In this reference mention may be made of income per head per day and population density in the region and around. If the region is densely populated, whatever be the plan, it is very likely that the people in the region will try to have some more residential constructions on land than to green it, and will act accordingly. Further the more the income level of the people, the more they will try to grow facilities, amenities and luxury items over a piece of land than to grow greenery on it regardless of what is written in black & white in the plan. The people in the region will allow attempts to grow greenery, with sincerity commensurate to these facts and hence the results will follow. With these points in mind an attempt was made to identify the factors controlling the LUP change in CMAs.

The above problem is persistent inspite of the National Forest Policy and the country-wide realisation about the need of 33% forest-cover and the facts that India was having even less than 20% of it (Vadiya 1987), and the Asia Pacific region is loosing forest cover by 1.6%/year (Mohanty, 2001). Moreover, even after country-wide (including mining areas) green-revolution, green cover over the coal mining areas has decreased significantly. The above fact points towards some unidentified lacuna in the presently followed technology of coal-mining or in the procedure of some of its associated activities e.g. reclamation, reclamation planning or land-use planning system (Ghosh & Rani, 1999). This is definitely adding to the damage to forest cover the country is facing. Hence the changes faced by LUP in CMAs are not eco-friendly.

In view of the above inference, it is recommended that the short coming(s) should be identified and removed. All activities of coal-mining and reclamation should proceed as per plans developed before initiation of the project activity, of which LUPg should be the first step. The total planning system specially that of LUPg should be revised and remodelled wherever and whenever required.

7.4.7 Factors controlling the LUP change in CMAs

On an attempt to identify the controlling factor(s) it was noted that change in LUP in mining areas is caused not only due to mining; its snow-balling effect continues upto much larger area and once the "cycle of land degradation" starts, it goes on working in accelerated speed unless forcefully stopped. When land-reclamation or greening activity is conducted in mining areas, the lands taken care of are generally only those lands which are directly or visibly disturbed by mining e.g. quarry or fire-areas; while the remaining areas develop their own land-use by nature's care only. This variety of land (uncared by men) is many times more in areal extent than the cared (by men) variety. Thus when the mining areas are considered in total to study LUP, the actual situations are impacted mainly by the LUP generated by nature's care and disturbed by human activities, e.g. mining, construction etc. which in turn again are controlled to some extent by natural conditions. The final LUP generated in mining areas is an expression of interaction of all the natural and human induced factors, including human efforts for greening the lands. The idea bears some parallelism with the concept that in many cases natural factors provide limitations and potentials of land for particular use (Spangle et al. 1976). Further, the basic control for impact of coal-mining on land-use pattern lies with availability of mineable coal seam(s) which is again a geologic and natural factor. This "nature" includes climatic, physiographic (including drainage), geologic and soil conditions (nature, thickness etc), and even demographic conditions (population density, income status etc.) all of which effect the mining activity. Naturally mining criteria like excavation details (depth, thickness, etc.), life of mine, area of mining, etc all are effected by natural and geologic factors and in turn have some control on impact of mining on land-use of the area. Thus the final LUP developed (i.e. the post mining LUP) is an expression of interaction between all these natural, demographic/social and human induced factors. The quality and quantity of effort to develop a certain LUP made by the population around an area is dependent upon mainly human interference on the land which in turn is dependent upon the density, and education of the population. Hence the income status of the same population, also controls the final LUP. Again the degree of damage to LUP is decided by the mining details and hence poses limitations or potentials of that particular land to develop certain land-use. Further its soil (quality and thickness), topography, water availability etc. will control the development. This concept is corroborated by the concept of Karunakaran (1982) who mentioned that the manner in which the environment is modified, degraded or conserved depends largely on the type of interaction between the different natural parameters and on the type and degree of human interference. These natural parameters are, in all probability mainly geologic and geomorphologic. Further it was mentioned that in order to mitigate environmental degradations caused by mining operations, it is necessary that environmental geological and geomorphological considerations are given due importance. To some extent some parallel idea have been evolved by some recent study in Jharia coalfield (Mukherjee 1999 & Raju 1999).

Thus it appeared that, the impacts of coal-mining on LUP is controlled by some geologic, human and natural factors. Any plan to minimise such impacts will not be successful unless the quality and quantity of control of such factors are properly understood and taken care of. Further data treatment and analysis was done giving due importance to this fact considering henceforth geologic factors also as natural factors.

Considering previous literature in this subject (Spangale *et al.*, 1976, Karunakaran, 1982) and standard knowledge of environmental geology, a list of 13 possible factors (natural, human, social) was prepared which could have some control on change in LUP in CMAs.

The possible controlling factors identified are represented henceforth by the respective abbreviations as listed below, grouped as per the nature of control they provide.

A. Factors having direct control:

1. Surface water availability; **SW**
2. Topographic set-up; **T**
3. Rainfall; **R**
4. Soil cover; **SC**
5. Rock Type ; **RT**

B. Factors having indirect control:

6. Excavation Depth; **ED**
7. Excavation thickness; **ET**
8. Project Area; **PA**
9. Life of Mine; **LM**

C. Factors with more indirect control:

10. Fault; **FT**
11. Strata dip; **SD**
12. Income per head/day ; **I**
13. Population density; **PD**

7.4.8 Magnitude of control of the factors

On thorough anlysis of the data on LUP change in CMAs and the possible factor(s) controlling such change in all the thirtyone (31) sample cases it was realised that the quality and quantity of LUP change varies with the conditions of these possible factors.

Thus the total range of conditions (present in field) of each such factor was classified into five (5) class intervals, A to E so that class A refers to most suitable, and gradually through other classes class E refers to the toughest conditions for sustainable greening. The samples falling in each class interval were classified. Next detailed analysis was conducted with samples falling in class A, class C and class E to know the change in LUP of CMAs under most, moderate and worst eco-friendly conditions.

From the data set those cases falling in classes A, C and E were selected and analysed to get the respective equations for each of the thirteen (13) controlling factors identified, for A, C and E cases. Thus three sets of 13 equations were obtained for moderate (Rani & Ghosh, 1999), best and worst ecofriendly conditions.

From these three sets, three analytical hierarchies were established about the capacity of these factors to allow LUP change in CMAs under most, moderate and worst ecofriendly set of conditions, which were marked as H_1, H_2 and H_3 respectively.

From each of these hierarchies the top five (5) were considered as powerful controlling factors interfering in LUP change in CMAs and the five respective equations (from each of the three sets of 13 equations) were selected for further analysis.

Next the method of Gausian elimination, (which is a standard direct method to solve the linear systems), was applied to get the capacity of the five powerful natural/social factors to influence the change of the respective LUP components by unit area mining under most, moderate and worst eco-friendly conditions. The equations obtained are listed next as C_1, C_2 and C_3 respectively.

$$-1.535\,(F) - 0.158\,(C) + 0.421\,(W) - 0.475\,(B) - 0.172\,(O) = 1 \quad \ldots\ldots\ldots\ldots\ldots\; C_1$$

$$-3.821\,(F) - 2.318\,(C) - 7.713\,(W) - 5.236\,(B) - 2.288\,(O) = 1 \quad \ldots\ldots\ldots\ldots\ldots\; C_2$$

$$-2.781\,(F) - 0.073\,(C) + 0.406\,(W) + 0.598\,(B) - 0.291\,(O) = 1 \quad \ldots\ldots\ldots\ldots\ldots\; C_3$$

(Ghosh & Rani, 2001).

In right hand side of each equation "1" stands for unit area mining.

These three equations indicate the amount of land-uses disturbed by mining related activities (and mining) but escape the attention while LUMP are prepared for CMAs, in all probability because the damages are not the direct effects of mining.

7.4.9 Recommendations

From the study it has been recommended that when any coal mining is to be conducted the amount of area to be mined should be noted from the mine plan. The geological and social conditions in the area should be examined to know the level of eco-friendlyness of the region. Next the respective equation suitable for the region should be consulted to know the amount of forest area and cultivation land to be lost due to that mining even after applying usual plantation activities which are conducted generally to green the mining degraded lands. Hence the LUPg should take care that an equivalent amount of land in addition to the land directly degraded by mining should be attempted to green (in terms of plantation and or agriculture) so that in the long run the region will face no further decrease of green cover.

Such studies can be conducted for all varieties of MAs to generate some guidelines for LUPg for MAs.