Problems of Mine Water Drainage due to Damage to Hydrologic Amenities in a Coalfield—A Case of a Coal Bearing Area in India

By R. GHOSH[1] and D. K. SINHA[1]

Indian School of Mines, Dhanbad-826004, Bihar, INDIA.

ABSTRACT

Coal Mining in India had been confined in the past primarily to two or three coalfields. Unscientific mining has led to huge degradation of land including massive subsidence of strata and disturbances of water tables to a wide extent. This has caused problems not only in flooding of mines from surface water but also in further planning of the surface drainage for current mining activities. Now, therefore, surface hydrology and land-use potentialities of the area have been endangered inflicting severe damage to the overall environment and ecology of the area.

The paper discusses certain investigative aspects of the problems highlighted as above in one of the coalfields, and encompasses mainly the following areas :

1) Quantitative estimation of the damage already done to the natural surface drainage system. For this purpose damage to topography and drainage for the last fifty years have been made out through the aerial photographs and topographic map sheets

2) Analysis and comparison of different states of such photographs are carried through to indicate the extent of damage to the hydrological conditions inducing undesirable changes in its land-use pattern.

Based on the analysis, concrete suggestions are made to restore the water drainage system which will be most suitable for future mining in the area containing high grade coal. The design and planning of the drainage system is based on the total system approach including the cost benefit analysis as well as hydrological considerations.

INTRODUCTION

Developing natural resources is a compulsion for any progress oriented society. Increase in mining activities therefore is a stepping stone for development. But unless such activities are carried out with proper care for environmental protection,they cause serious degradation in topography, natural drainage pattern, rainfall etc, and consequently deplete the green coverage and other beneficial aspects of landuse pattern.

With an annual coal production of about 160 000 m.kg. currently, India is one of the notable coal producing countries over the world. Its past mining history, however, is not very bright from the point of view of environmental protection. The fact may be ilustrated well through a thorough study of a very important coalfield in eastern India - the Jharia coalfield.

Jharia coal field, being the main store house of prime coking coal in India,started its mining history sometime in late 19th century. The speed of mining intensified in 1925(1) which, however, proceeded in a completely unplanned manner without any idea for reclamation, leaving quarries, overburden dumps and goafs completely uncared for. This has resulted in an uneven topography with waste dumps, quarries, goafs and subsidence and resulting fire zones. These have caused a major environmental imbalance over the area resulting in loss of its various natural resources including greeneries. Among various other factors, topography and natural drainage system are the two which have been severaly disturbed by mining, some such changes were also noticed by earlier workers (2). It might be worth while to mention here that since the nationalisation of coal mining industry in India in 1972/73, some healthy trends are noticeable in this regard. In the present paper an attempt has been made to bring out the damages caused to the natural hydrological system through the period between 1925 and 1974.

MINING VERSUS HYDROLOGY WITH REFERENCE TO JHARIA COALFIELD

Mining activities affect the hydrology of an area largely through changes induced in landscope pattern. Two significant effects of such changes are seen: hydrologic amenities and topographic characteristics.

Mining activities without reclamation alters the topography which in turn effects the active regime of both surface and subsurface hydrologic flows. The volume of surface run-off and its percolation into subterranian areas get altered in the process by silting due to overburden dump washing and consequent disruption of balance in water bodies This in turn causes a reduction in total water resources over the area.

When mining activity is carried out below ground-water level,a considerable volume of water flows into the operational face necessitating continuous pumping out of equivalent amounts of water on to the surface. If a proper plan for drainage of such pumped out water is not designed, this volume of water would be cut off from the water table and cause a damage to the water resources and the regional water table. This, consequently forces a change in the land quality and land use pattern. A single colliery (Sudamdih) in Jharia coalfield needs pumping out of 0.18 m^3/sec in summer. Total amount of water being pumped out for this purpose from coalmines alone, occuring in different parts of India is of the order of 142.12 m^3/sec.

Many mineral deposits including some coals are highly permeable so much so that they become a component of hydrologic system. Gray(5) in this context concluded that exploitation of such bodies will induce changes in water table and hence the available water resources in the region. A case at point is the Neyveli Lignite field, India, where the water table has been found lowered considerably due to mining (6) which needs a regular pumping out of water at the rate of 6.37 m^3/sec. (4). Uncontrolled discharge of such huge amount of mine water causes various problems : If the pumped out water reaches a rock which is not amply porous, or a river channel, parts of which have already been silted, it creates flood over the region. On the other hand, a major portion of flood water gets evaporated during flowage and completes the hydrologic cycle too late to reacharge the ground water and thus disrupts the stability of water table. Such damages are common and reflected much over the surface hydrological amenities in Jharia coalfield.

If a left-over goaf (void underground) is filled up by mine water percolated through subsided surface above, it may maintain a high pressure against the walls of the goaf. The situation becomes more difficult due to non-availability of any plan or record of such "out of sight" old workings. Such unrecorded, unprotected, unmanaged and unforeseen collections of mine water drainage rush over present-day mining sites nearby, when the separating wall becomes unknowingly,too thin to resist the forceofold water collections. This creates difficulty in planning the present-day mines over the region. Such a dangerous problem occurred in Chasnala Colliery in recent past.

The main outlet of the natural drainage system in Jharia Coalfield is the Damodar river along with its several tributaries and lower order tributaries. An attempt has been made here to estimate the damage caused to this natural drainage system in the area by mining activities. With this in view, analysis of the regional topography and drainage system has been made on the two time horizons - prior to the year 1925 and upto 1974, The first one would indicate original features before significant mining activities started here, while the second one depicts these features as they were changed due to mining activities, mostly under the control of small private ownerships before nationalisation of this industry.

METHODOLOGY OF INVESTIGATION

Studies for this purpose have been made by detail analysis of aerial photographs (1 : 40,000) and toposheets (1 : 50,000) of 1974, and toposheets of 1925. Estimate of degradation in hydrologic condition has been made using two parameters : (1) damage caused in natural drainage system and (2) decrease in water level flowing through the river Damodar, which forms the main artery of the natural drainage system here. Fig.1 illustrates the drainage network as it existed in 1925 while Fig. 2 represents the drainage net work of 1974. A comparison of these two figures show that although the major components of the drainage system comprising the river Damodar and its main tributaries have not changed the overall surface hydrologic condition has been damaged significantly through the period. Many of the lower order tributaries have been dried up or lost altogether. A through investigation for the actual cause of this damage shows some of them have been intercepted by quarries, still others have been blocked by overburden dumps or their washings. There are others which have been lost due to subsidence, some have also been lost due to lowering of water table in close proximity to underground mining sites or percolation of water into the goaf. It has been estimated from Fig that a length of 355,000 m of natural surface drainage (except Damodar) was in existence in the field in 1925 while the figure for 1974 stands at 211,000 m. Thus between 1925 and 1974, 144 ,000 m of natural surface drainage has been lost in the area. Unplanned mining activities under previous ownership, paid scant regards for environmental protection/mine water drainage management or even ground water recharge, which appears to be the prime cause for this substantial damage.

EFFECT ON LAND USE

The most visible effect of the degradation in hydrologic system and topography of the area is seen in the change in landuse pattern at the respective time levels. A study of the land use maps prepared following USGS suggestion(7) for the area for 1925 (Fig.3) (8) and 1974 (Fig.4),(9) and their comparison in table 1 clearly reveals a considerable deterioration in land use patterns. The landuse map of 1974 has been prepared through thorough study of **aerial** photographs of 1974.

Among the changes, first to note is the amount of quarry and overburden dump covered area which has been increased much during the period. Among the various other changes, a very prominent one is that the forest covered land has decreased from **4.9% in 1925 to 0.7%** in 1974. All other types of green belts including light vegetation and cultivation amounted to 56.8% in 1974 against 65.4% in 1925. This substantive loss of greenery appears to be a direct effect of degradation in hydrologic conditions and damage to topography caused by unplanned mining and mine water drainage.

EFFECT ON RAINFALL

Observation on changes in amount of rainfall in the area through sixty years between 1924 - 1983 have also been included. The data received by courtesy of the D.V.C. have been averaged for each ten years (Table-2). This clearly shows a substantive decrease in rainfall through these years. The change in the level of water flowing through the river Damodar have been studied for the present work. The data relates to the water level in monsoon months from 1969 to 1973 (Table-3). It reveals a decrease in the level of water flowing through Damodar river which, as stated earlier, is the main component of drainage system here. This certainly appears to be directly correlatable to such factors as drying up of stream chanels vis-a-vis loss in length of natural drainage system and decrease in rainfall.

COST BENEFITS OF POSSIBLE SOLUTIONS

There may be three possible systems of mine water drainage: (a) discharge through pipelines into already existing water bodies near settlement areas (b) discharge through main channels leading to the major river over the field (c) discharge through smaller drains into any tributary near the pumping site. The total amount of water to be discharged over the field is, estimated as 43.46 m^3/sec.(4). This huge amount of drainage needs to be managed by any of the above mentioned method. It has been estimated that if the first method is followed, a pipe length of about

30,000 m • will be required, which once prepared will not need any maintenance cost, unless mechanically damaged. Moreover this method will damage landuse at a minimum. While on the otherhand, if discharge is planned to manage following the second alternative procedure, it will require about 50,000 m• of channels damaging landuse of the region to a considerable amount. Moreover such straight channels will not be possible to dig due to land damage caused by previous mining; also it will need regular maintenance cost through dredging and others to avoid effects of siltation. If the third alternative system is followed for managing the mine water discharge, the length of channel needed may be less but, even in that case, the investment and maintenance cost over the period appear to be considerably high. Judging the whole situation, the first alternative is estimated to be the least costly one.

CONCLUSIONS AND SUGGESTIONS

The investigations clearly establish that unplanned mining has led to improper mine water drainage causing damage to topography, loss of natural surface drainage, loss of greeneries, decrease in rainfall and lowering of water level flowing through the river over the field. All these environmental parameters are related, one being the cause of the other and vice-versa: basic of all these is unplanned mine water drainage. This has damaged the water potentialities over the region. The final result of all these is a serious ecologic and environmental imbalance leading to a severe drought, which the area faces in every summer. This situation calls for a proper planning to restore the natural drainage system over the area. To suggest for mine water drainage management over a newly opening mining project is a more easy job than to suggest something for such an invisibly damaged area. This however needs some specific steps.

1. To fill up all the abandoned quarries and detected unfilled goafs using overburden dumps and unwanted hillocks (natural or artificial). Goaf filling should be given the first priority. If all the unwanted mounds and hillocks be used up, some abandoned quarries may be left unfilled to be used for future water resource. The natural drainage system should be kept free of any overburden dump nearby and thus, free of any chance of silting.

2. Mining should be carried out uniformly in successive sectors, with strategies not to damage any surface water body. Mining should be started from outcrop fringes and proceeded gradually towards dip. Continuous back filling must be done, proceeding gradually from opencast to underground mines. Continuous reclamation method (7) is the best suited one for the opencast blocks. For underground mines stowing is to be preferred over caving.

3. Any amount of mine water drainage should be poured through pipes (not drain or channel) into existing water bodies, away from the mining site and nearer to settlement areas. It thus becomes a multipurpose project; on one hand, by adding the water, through a pipe line into an already existing water body chances of additional percolation and evaporation will be minimised.The added supply of water, if maintained and preserved thus, may restore the water supply to the settlement areas probably even up to dry seasons. On the other hand the water will reach the water table of the mining site late. This late recharge will minimise the necessity of pumping out of mine water.

4. The settlement sewerage (generated by using this water) should be directed to pour into settling and treatment tanks. The good quality water coming out of these tanks should be poured into recharge wells or recharge pits so that it may reach the ground water to restore and stabilise the water table. Such receiving water bodies, if possible, may be covered to avoid unwanted evaporation.

5. The overburden dumping grounds should be carefully selected so that no problems out of siltation of surface water bodies may result. Protection of such dumps against washing is also a matter to be considered.

REFERENCES

1. Fox,C.S. The Jharia Coalfield, Mem GSI Vol.56.(1930)

2. Mehta,D.R.S. Revision of the Geology of coal resources of Jharia Coalfield. Mem. GSI.Vol.84 pt.2 (1957)

3. Baliga,B.P. Qualitative and quantitative enumeration of environmental problems associated with coal mining Industry. Rep.DOE,GOI. (1986)

4. DGMS,Bihar, India,Report Vol.1 p.130(1984).

5. Gray,Mc. I· Simulation of the effects of surface mining on ground water in the Powder river basin. Min.Eng.Vol 31,No.4 pp 9-15 (1979).

6. Singh,D.P. & Sarma,K.S. Reclamation - An environmental control. Nat.Sem. Minerals & Ecology,ISM,Dhanbad,Bihar,India (1982).

7. Coates,D.R. Environmental Geology,Wiley, New York (1981).

8. Ghosh,Rekha. Geological considerations for urban development in Jharia coalfield, Eastern India. Int.Sem. LANDPLAN III, Hongkong (1986)

9. Ghosh,Rekha. Land use and Land protection in mining areas - A case study in Jharia coalfield. J.Geol.Soc.Ind.Vol.29,No.2 pp 250-255 (1987)

TABLE-3: AVERAGE WATER LEVEL IN RIVER DAMODAR (ABOVE SEA LEVEL, IN METRES).

Year	June	July	August	September	October
1969	139.22	140.20	140.72	140.64	139.85
1973	138.55	139.58	140.02	139.88	139.15

TABLE-I: LAND USE PATTERN IN JHARIA COALFIELD 1974 AND 1925 COMPARED

Land use pattern	% of area covered in 1974	% of area covered in 1925
1. Settlement	16.0	8.6
2. Quarry	12.7	2.4
3. Rock outcrop/ overburden dump	4.7	2.3
4. Water body and river sand	6.7	7.3
5. Forest/Wood	0.7	4.9
6. Cultivation	45.5	65.4
7. Natural vegetation	11.3	
8. Fallow/grass land	2.4	9.1

TABLE-2: MONTHLY RAINFALL THROUGH 60 YEARS IN JHARIA COALFIELD AVERAGED FOR EACH TEN YEARS (IN METRES)

Year	June	July	August	September	October
1924-33	.157	.444(.601)	.335(.936)	.185(1.121)	.093(1.214)
1934-43	.171	.338(.509)	.363(.872)	.234(1.106)	.084(1.190)
1944-53	.185	.364(.549)	.324(.873)	.219(1.092)	.084(1.176)
1954-63	.146	.307(.453)	.264(.717)	.257(0.974)	.104(1.078)
1964-73	.169	.298(.467)	.332(.799)	.230(1.029)	.071(1.100)
1974-83	.182	.318(.500)	.226(.726)	.233(0.959)	.056(.1.015)

N.B.: Cumulative values have been given within brackets.

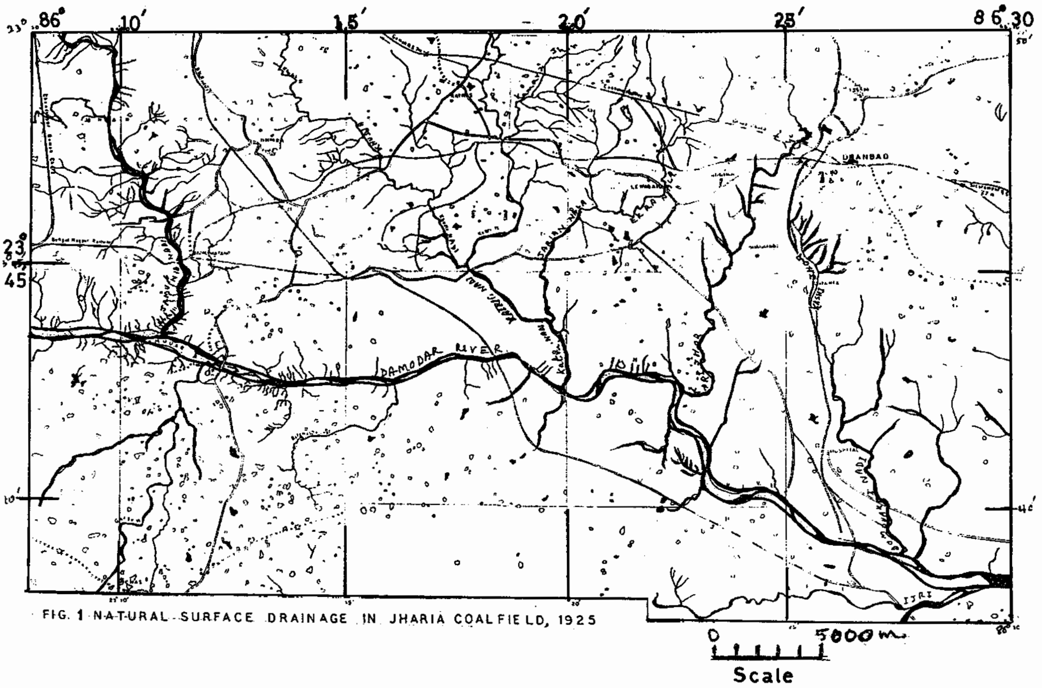

FIG. 1 NATURAL SURFACE DRAINAGE IN JHARIA COALFIELD, 1925

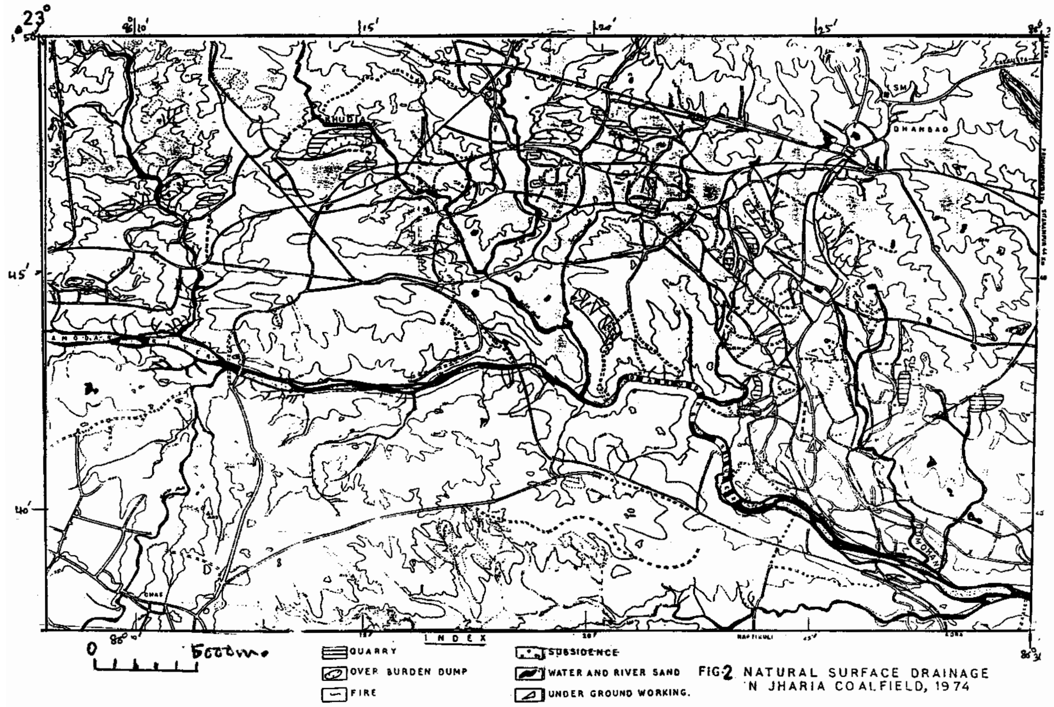

FIG 2 NATURAL SURFACE DRAINAGE IN JHARIA COALFIELD, 1974

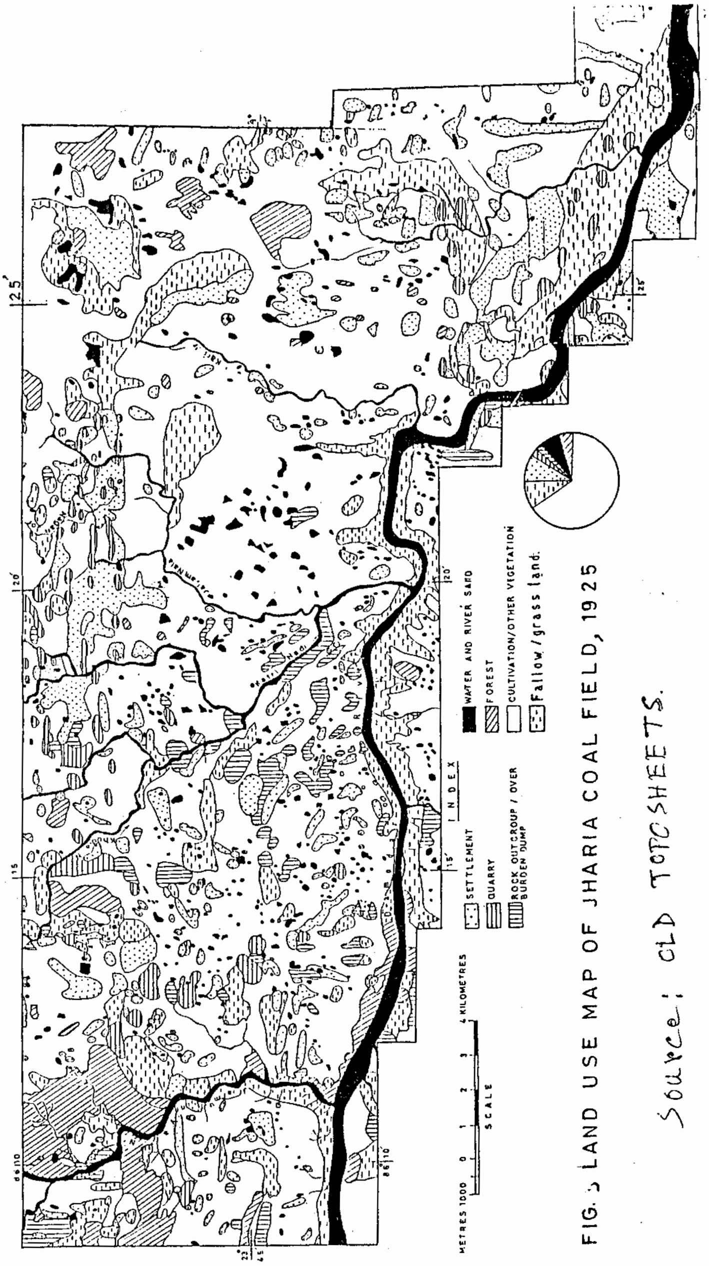

FIG. 5 LAND USE MAP OF JHARIA COAL FIELD, 1925

Source: OLD TOPOSHEETS.

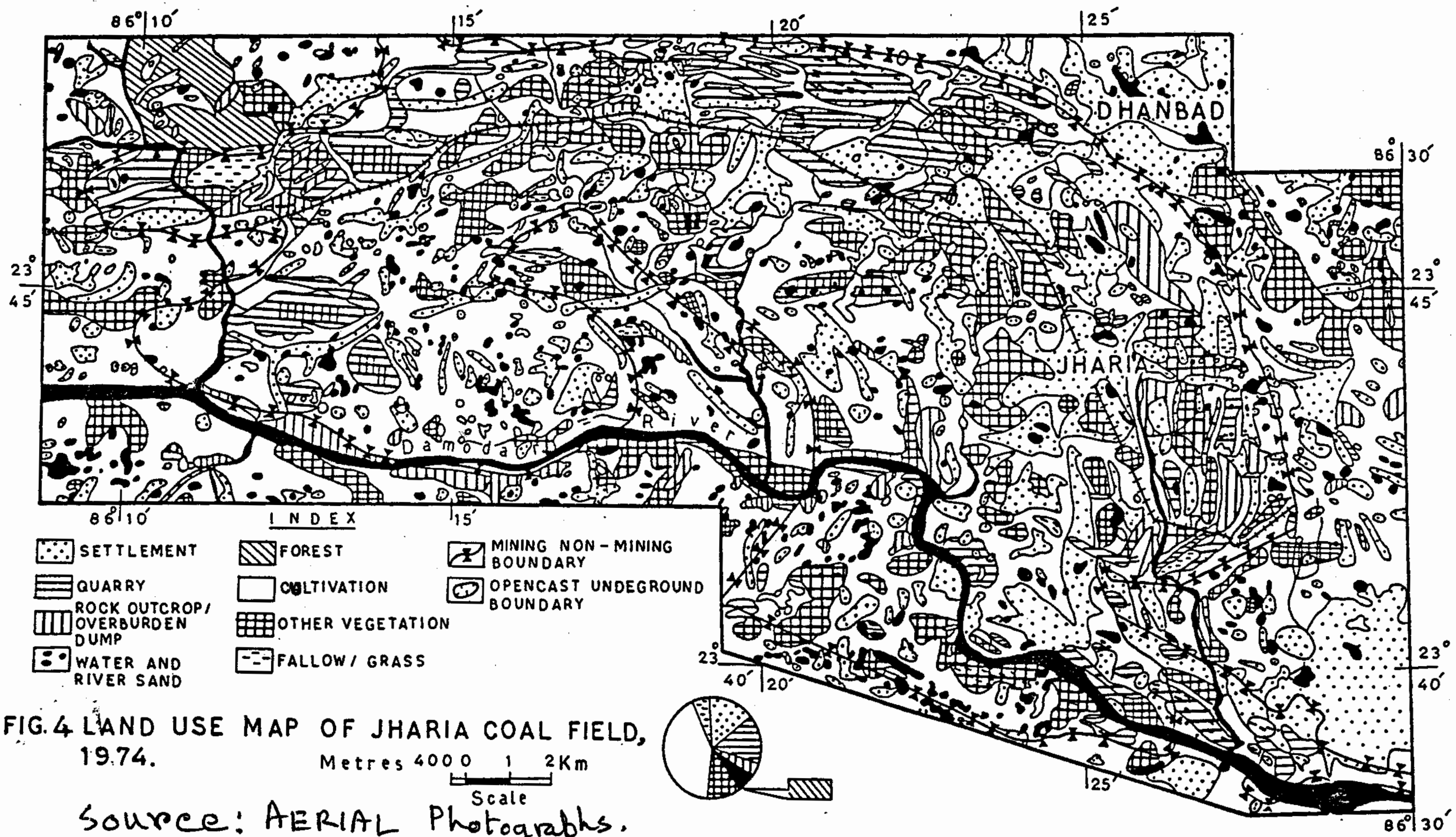

FIG.4 LAND USE MAP OF JHARIA COAL FIELD, 1974.

Source: AERIAL Photographs.