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Interface At Raniganj Coalfield In Barddhaman District, West Bengal, India

Mahamaya Laha, Arambagh, Hooghly, West Bengal

Abstract

In Raniganj Coalfield of western Barddhaman, West Bengal, India the original scheduled caste inhabitants had a forest-based economy. Forest economy dies up when coalmines are opened up. Demand of safe drinking water increases by this advanced society. In underground mining groundwater is disposed to the surface. It meets various needs, e g, drinking, domestic and agricultural need as well as needs in colliery itself, enriching surface water bodies and so on in this water-crisis region. But evacuation of both solid coal and liquid water disturbs the hydrostatic balance. It results into mine hazards like roof fall, subsidence, mine fire, mine inundation etc. Thus the transformation of action space from forest based to mining based one by an alien social group superposed on the pre-existing social space brings environmental hazards and it directly affects the poor original social groups living at slums.

Introduction

History of the Western Barddhaman, West Bengal unfolds the history of coal mining in the Raniganj Coalfield, the oldest coal mining area of India. Commercial coal mining started in 1774 (CMPDI 1982) and It was a threshold in space perception, spatial process, spatial organisation and space-society relationship as well. The dense forest of the Western Barddhaman was the abode of local scheduled caste people who used to live on the forest products and the rudimentary subsistence agriculture. Because of low level of economic development, demand for domestic water and fuel was low. The domestic need of water used to be met by the Ajay, Barakar and Damodar rivers for the riverine settlements and by the Nunia, Tamla, Singaran etc, nalas for the interior settlements. Fuel used to be collected from local forest of the Junglemahal area. Coal mining is started by the colonial people to meet the demand of coal in Britain after Industrial Revolution and to serve Indian railways. Coal mining brings about significant and abrupt changes in socio-economic and spatial processes. New settlements grew up. A diversified social comprising tribal mine workers from the Chotanagpur plateau, Punjabi drivers, South Indian accountants, Kolkatan mine owners, engineers and supervisors, is superposed upon the native one. Increasing population increases the demand of water. Wells are dug up. Thus coal mining is the first phase of functionalisation and commercialisation of groundwater in true sense in the study area.

Objectives

The basic objective is to study the interaction between mining, groundwater, space and society and its spatio- social consequences in the Raniganj Coalfield area. Major questions to be addressed are:

i) Under what economic imperatives coal mining was introduced in this part of India?

ii) To what extent groundwater in coal mines can be treated as a resource? and

iii) Under what condition groundwater does become hazardous for space and society?

Methodology

History of coal mining, geological background of the study area, hydrogeological characteristics and geochemistry of groundwater have been analysed at the beginning by using secondary data. The discussion focuses on dewatering of mines and resource potentialities of mine water. For this, several collieries have been visited. The discussion ends with disasters accrued on interaction between coal mining and groundwater extraction. Finally a model has been prepared to analyse the changes in space through the interaction with coal mining and groundwater by the society.

In this study some limitations are also there. The amount of groundwater responsible for subsidence cannot be calculated because both the coal and groundwater are together responsible for this. The use of mine water in agriculture has been observed but no recorded data is available. No information is at hand about the permanent water table of mining area.

Discussion

The discussion begins with the brief history of coal mining, the geology, lithology and groundwater situation of coal mining area.

4.1 History

In India the colonial rulers for coal reserves to meet their industrial need in Europe and need of rail engine in India. Being nearer to Raniganj Coalfield selected for mining. Before commercial mining was a virgin *sal (Shorea robusta)* forest (Rennel's Map 1783, Petterson 1997) and was a part of the 'Junglemahal' district which was not a revenue district but purely administrative one. Probably foreseeing an economic thrust to this place the Maharajas (landlords) of Barddhaman the proposal of opening collieries here. Collieries up primarily as open cast mines and later underground mining up to the scenario. Spatio-social changes go on. Coal mines have been nationalised in 1972. ECL takes lease of 640km^2 out of 1084km^2 coalfield area (CMPDI 1982), which comprises eleven mining areas: Mugma (Jharkhand), Salanpur, Sodepur, Sripur, Satgram, Kunustoria, Kenda, Kajora, Sonpur-Bazari, Bankola, Jhanjra and Pandaveswar from west to east. Presently (2009 November) there are 68 working collieries and 23 abandoned collieries in Raniganj Coalfield, Barddhaman district.

Geology

Raniganj Coalfield is the eastern most part of Damodar Valley located in Gondwana basin. During Lower Gondwana age (Lower Permian to Lower Triassic period). Stratigraphically, it is divided into three series – Panchet, Damuda and Talchir (Fig:1, see page 33). They are comprised of mainly sandstone (fine and coarse), shale and coal. Coal seams occur only in Damuda series (Raniganj and Barakar formations). Large scale faulting, tilting place after the closure of Gondwana sedimentary deposit.

Faults and intrusions of mica-peridotite sills and dykes affect coal seams. Besides sandstone and shale patches of hard rock outcrops (granite, gneiss and schist) of Archaean era occur to the extreme west and eastward lateritic soil occurs above the sandstone and shale layers (The geological map of Raniganj Coalfield area by Eastern Coalfield Ltd. 1962, Coal Atlas of India 1993, of Geological Survey of India Vol. 88, 1977).

4.3 Lithology and Groundwater

The borehole lithologs show that there is 5-20m thick weathered zone on granite, sandstone and shale rocks. They form perched aquifers at the top. The permanent aquifer is formed by sandstone layer in areas affected by fault, fracture, joints or lineaments etc. Fine grain sandstones are common to the south (Asansol, Raniganj, Kulti blocks) and coarse grain sandstones to the north (Jamuria, Barabani) and east (Andal) in the lithology of the Raniganj Coalfield (Fig. 1). On an average sandstone layers are 3-15m thick and shale or shale intercalated with sandstone layers are 1-2m thick, but occurrence of sandstone is less frequent (4 to 8 layers) than the (10 to 20 layers). However all the sandstone layers may not form aquifers. Yield of tubewell however varies under different geological set up. In Archaean granitic rock area it is only 5m^3/hour and in Gondwana sedimentary rock area it is <50m^3/hour (CGWB 1998).

The groundwater level of perched aquifer lies at a depth of 1-3m during post monsoon and at 3 -7m during pre-monsoon season. In some pockets of Raniganj and Jamuria police stations groundwater level is relatively lower. Much of the regional water table of coalfield area is unknown. It occurs at 50-80m depth. Besides the natural faults, anthropological interference like blasting in coal mine weakens the compactness of rock and enhances its aquifer potentiality (Radhakrishna 1971). Further, abandoned coal mine caves act as reservoir and yield of tubewell from there may 100m^3/hour (CGWB 1998).

4.4 Geochemistry of Groundwater

Geochemistry of groundwater is necessary as sometimes it's used for drinking purposes. The study of geochemistry of dugwell water from 1997 to 2004 shows that the concentration of total hardness, specific conductivity, total dissolved solids (TDS) and chloride high, near or sometimes above maximum permissible limit for drinking during 1997 to 2000, but on an average it around the maximum desirable limit during 2001 to 2004. However in case of mine water the concentrations of iron, TDS, total hardness, chloride, specific conductivity etc, remain much below the maximum permissible limits and sometimes below the maximum desirable limits also as mine water is less exposed to surface and atmospheric pollutants than the dugwell water is. But levels of BOD, COD and bacterial concentration are very high for drinking in some of the collieries like Kajora, Jhanjra, Ningha (Sripur), Mahabir (Kunustoria), Mithani and Dhemo Main (Sodepur) etc. So filtering is necessary before drinking this water. Analysis of about 35 mine water samples recorded by Asansol Mines Board of Health (1995-2001) on an average shows (Table: 1).

Table 1: Average Geochemistry of mine water.

No	Chemical Parameters	Permissible Limit (Drinking)		Actual concentration in study area
		WHO	Indian Standard	
	pH	7-8.5	7-8.5	7-8
	Turbidity (ntu)	5	5	6-10
	TDS (ppm)	500	500	300-500
	Iron (ppm)	0.3-1.0	0.3	0.05-0.3
	Ammonical Nitrogen (ppm)	0.1	0.1	0.2-1.6
	Total Hardness (ppm)	100-500	300	100-160
	Fluoride (ppm)	1.0	1.0-1.5	0.02-0.8
	Chloride (ppm)	200-600	250-1000	30-100
	Oil and grease (ppm)	0.01	0.01	trace to 0.8
	BOD	3	3	6-18
	COD	10	10	10-40
	MPN per 100ml	Nil	Nil	40-100 and even 1800+
	Faecal matter	Nil	Nil	Present

Source: Asansol Mines Board of Health, 2004.

Underground Mining and Technique of Dewatering

It is to be mentioned that the interaction of the society with groundwater was simple before mining. Dugwell is first step of interaction. In 1850 first underground mining started. Dewatering is a pre-requisite to collect coal from underground mines. The process is complex. Rainwater or surface water percolates through the pore space and lines of weakness of rock. This seepage water is channelised and stored in sumps, the natural or man-made underground reservoirs. Water is piped down from minor sumps to main sump at greater depth and from there it is pumped out of the mine. The dewatering pumps generally run all day long. That water is often stored in a surface reservoir for differential uses. The dewatering pumps run for 20 hours a day. Age old pumps lose its discharge capacity roughly by 10% and discharge equals to that of 18 hours pumping. However in some collieries discharge reduces a bit from December to May. Daily withdrawal of water in some surveyed collieries have been shown in Table:2.

Use of Mine Water

The Raniganj Coalfield area of Barddhaman is bounded by three perennial rivers, the Damodar, the Barakar and the Ajay. Other flowing water bodies are nalas (Nunia, Tamla, Tumuni, Singaran etc,) and jores (Tanti, Amrasota, Jorejanki etc,). Though

Table 2: Daily extraction of mine water from selected collieries, Raniganj Coalfield

Name of Colliery/mine area/ Year of openings	No. of Pumps	Pumping Capacity in gpm	Daily extraction of water (gallon)
Kunustoria (Kunustoria) 1962	4	500	500×60×18×4=21,60,000
Amritnagar (Kunustoria) 1949 i) Bogra Pit	1 1 1	500 300 500	500×60×18×1=5,40,000 (A) 300×60×18×1=3,24,000 (B) 500×60×9×1=2,70,000 (C) (A+B+C) = 11,34,000
ii) Narainkuri Pit	4 4 1	500 450 150	500×60×18×4=21,60,000 (A) 450×60×18×4=19,44,000 (B) 150×60×18×1=1,62,000 (C) (A+B+C)= 42,66,000
Ningha (Sripur) 1920	4	845	845×60×20×4=40,56,000
Chinakuri (Sodepur) 1955	2	500	500×60×18×2=10,80,000
Sarpi (Bankola)	3	300	300×60×18×3=6,48,000
Khas Kajora pit 11 (Kajora) 1852	3	1000	1000×60×18×3= 32,40,000
Haripur (Kenda) 1962	5	450	450×60×18×5= 24,30,000

Source: Field Survey, 2005 & 2009

dugwells, tubewells and Public Health Engineering (PHE) water supply are there, still water shortage occurs at remote villages. To compensate this shortage mine water is used for domestic or agricultural purposes by the local people and it meets some needs of the colliery also.

a) Mine water stored at surface reservoir is piped to the colliery colonies. It's used for cleaning and washing utensils, clothes, houses, vehicles and for gardening etc. When the reservoir overflows, the water is drained outside the colliery and it meets the same needs of poor people in slum areas. Sometimes mine water is directly disposed out of the colliery, e g, at Shyamsundar and Sarpi colliery of Bankola area, Kunustoria colliery of Kunustoria area etc. In some collieries, e g, Kunustoria, Kajora, Haripur etc, water is filtered by passing it through sedimentation bed, filtration tank (with alam) and sand bed. Finally bleaching is added to this filtered water. In Khas Kajora colliery daily capacity of filtration tank is 30 lakh gallons, in Haripur 75,000 gallons etc. This filtered water is used for drinking purposes in the colliery colony and the surplus is sent to the crisis areas by water tanks.

b) Within the colliery the workers at the end of the day's work wash themselves or take a bath using stored mine water at reservoir. Stored water is used for washing office rooms and toilets also.

The collieries that are opened before1950, run their mining machineries by boiler and steam engine, e g, there are four boilers at Ningha colliery, two each at Amritnagar and Khas Kajora colliery, one at Kunustoria colliery and so on. Boilers require 10,000 – 1,00,000 gallons of water.

Much of the Kunustoria and Satgram area is standing over stook, goaf and cave (Bhattacharya 1997). So stowing is necessary to avoid roof fall and subsidence. During stowing or sand filling mine water is used as lubricant along with the sand. Stowing requires around 4.5 lakh gallons of water at Kunustoria and Lower Kenda colliery, 9.5 lakh gallons of water at Amritnagar, Khas Kajora colliery daily. However water consumption in Amritnagar has been reduced (2005) due to the completion of stowing at one site there.

To extend mining activities new working sites are opened up. In Sarpi colliery (Bankola area) mine water of existing pit had been used for moistening and loosening the surface material before opening a new pit during January 2001.

Sripur colliery had a rudimentary technique of cooling the towers of thermal power unit within the colliery. Water used to be sprung up from surface reservoir of mine water for cooling purposes. Now it's an abandoned colliery.

c) Agriculture in the western Barddhaman is entirely rain dependent. Tank and well water are also used. Again the surplus mine water after filling the surface reservoir is drained outside the colliery. Small farmers of surrounding area use this water at free of cost, e g, Bhanora and many other collieries of Sripur area help to grow vegetables throughout the year by supplying even the mine water of abandoned collieries.

Presently (2004), eleven abandoned waterlogged mines have been selected by CMPDI to be used for irrigational purposes.

d) Fishing is practised by local people in small subsided depressions (e g, at Sarpi colliery, Lower Kenda colliery) where rain water or disposed mine water are collected. Jhanjra Colliery Project in Andal also keeps provision for pisciculture from mine water.

e) Brick kilns at the urban fringe and most of the collieries, e g, Sarpi near Ukhra town have brick kilns. The soil is moistened by mine water for manufacturing bricks.

f) Opencast pits collect rain water and seepage water as well. Sometimes they form lake, but they are of no domestic use for sudden increase in slope. Nine such abandoned open cast pits have been identified by CMPDI (2005) to decorate them with some recreational qualities like park, boating facility etc. This may attract tourists.

g) Collieries away from GT road use mine water to curb dust pollution from unmetalled or morrum-covered roads of surrounding villages. A tank sprinkles water on the dusty roads, e.g., the roads leading to Raniganj from Amritnagar and Mahabir collieries. Mine water is

Fig. 3: Changing pattern of interaction with groundwater in the mining area: a model

Interaction with groundwater	**Level of Technology**	**Effect on action space**	**Status of forest, a component of hydrological cycle**	**Character of social group and perception space**	**Level of Society**
Simple	Simple	Scattered dugwells as first level of interaction with groundwater	Dense sal Forest	Social groups like bauris, bagdis with forest based economy, poor perception on coal resource and low water demand	Simple
		More dugwells, horizontal expansion of action space, increasing density of interaction points with coal and groundwater	Removal of forest	Better perception on comparative advantage of Raniganj Coalfield at the expense of forest by colonial rulers, initiation of surface coal mining in 1774 and immigration of different socio-economic groups	
		Introduction of tubewells		More immigration, expansion of collieries and colliery settlements	
		Dewatering of mines, horizontal and vertical expansion of action space and increased interaction points with groundwater, rudimentary sectoral use of mine water	Increased removal of forest	Underground mining in 1850 and continuous immigration	
Complex and sophisticated	Complex and sophisticated	Use 1. domestic and drinking 2. use in colliery campus 3. boiler 4.sand stowing 5.agriculture 6. brick kiln 7. road repairing Hazard risk 1. roof fall	Recreation of vegetal cover	Expansion of underground mining and abandonment of mines	Complex
		a) crucial issue: 1. Commoditization of resource 2. avoidance of social hazard			

used for moistening and loosening the surface material also in the process of road repairing in remote villages, e g, repairing of unmetalled road leading to Searsol from Amritnagar colliery (2005).

h) Besides a number of economic benefits, mine water enriches natural surface water bodies also, e g, ponds, jores, nalas and rivers as the surplus water is left to nearby water bodies. The collieries, located on the bank of Damodar, directly dispose the mine water to this river, e g, Chinakuri (Sodepur), Damra, Ghushik, Tirat (Satgram) etc. Collieries also enrich the ephemeral streams, e g, Amritnagar and Mahabir colliery dispose water at Tanti jore, Kunustoria at Amrasota jore, Ningha, Girmint (Sripur) at Nunia Nala, Bansra (Kunustoria) and Lachipur (Kajora) colliery at Singaran nala etc. It helps to maintain their thalweg in summer.

This multi-phase use of groundwater increases the value of groundwater to the mining society. Though groundwater poses obstacle to underground mining, it's a resource to the existing society as a result of better perception of the space by the technologically advanced society. Again intensive removal of solid (coal) and liquid (groundwater) makes action space complex and brings various mine hazards on space.

Groundwater and Mine Hazard

In underground mining evacuation of solid (coal) and liquid (groundwater) phase creates void space below the ground. This requires sand filling. But it is often ignored because it increases the cost of coal production. As a result mining area faces negative changes on space like roof fall, subsidence, mine fire, mine inundation etc.

Blasting, dewatering and other mining processes disturb the hydrostatic balance. Falling from roof or cave wall may take place. Mining within 100m depth below the surface generally encourages roof fall. Continuous evacuation and expanding 'cave' enhances the disbalance of crustal surface. Subsidence may occur at points or over wider area. Survey on subsidence-prone area in Raniganj Coalfield, Barddhaman district by four different mining committees in 2002 (CMPDI, 2005) shows that there are 122 subsidence prone areas. Working mines occur within 100m depth below the ground in 80% cases. Horizontal extent of subsidence prone area is on an average 3ha and sometimes >10ha, e g, in Sripur area. Unfortunately, the poor scheduled caste people in slum areas are mostly affected by subsidence. During 2005-2009 the busy roads near Barakar bus stand and Sanctoria ECL office also subsidence. Presently subsided and subsidence prone areas occur over all the coal mine areas. There are 60 subsidence prone patches in Sripur area and around 30 patches in Satgram and Sodepur area (Fig. 2, see page 34).The field survey shows 6-7m deep point subsidence near Nimcha colliery and 2-3m deep areal subsidence near Amritnagar, Khas Kajora and Lower Kenda collieries.

After dewatering the mine air occupies the underground void. Oxidation instigates methane to catch fire easily. There are seven important wider areas of mine fire in Raniganj Coalfield (Saha 2004). Sripur, Sripur Rana (Sripur), Ratibati-2, JK Nagar (Satgram), Shankarpur (Bankola), Jambad (Kajora) etc, collieries catch mine fire

(Fig. 2). From 1989 to 2002 as many as 154 incidents of mine fire takes place in this region (ECL, 2005). The latest incident (November, 2009) of mine fire occurs at three pits of Kunustoria colliery (The Statesman 2 Nov 2009).

Excessive seepage or inrush of groundwater to the working mine also becomes hazardous by creating waterlogging and mine inundation problems. Seepage speeds up in the areas of structural weakness (faults) or to the dip of the bedrock. From 1975 to 2000 many collieries of Sripur area (Girmint, Bhanora, Jamuria, Sripur etc,) have been closed owing to drowning of pit through excessive seepage. If such a water-filled abandoned pit gets connected with a working pit below through a fault-plane or due to thinning of coal barrier (<60m) between them, mine inundation may take place (Rakesh *et al*, 1980; Kaku 2000). In 1989 inundation at Mahabir colliery (Kunustoria) takes the toll of six lives. Failure of main dewatering pump due to vibrations from explosives may also cause inundation, e g, at Chinakuri Colliery, 2005. From 1958 to 1999 there are twelve incidents of mine inundation in the district, e g, at Bara Dhemo, Ratibati New Ghushik etc, (ECL 2005).

Changing society and interaction with groundwater

In the Western Barddhaman prior to 1774 interaction with groundwater was negligible in absence of an economically motivated strong social force. Action space was dominated by forest based economy or by subsistence agriculture of low level. Groundwater therefore was not socio-economically significant except a limited number of dugwells. The first threshold is the opening of coal mines in this part of the Raniganj Coalfield by colonial rulers and Kolkatans. An alien social group with different socio-economic aims and objectives, is superposed on the pre-existing social groups. The action space is transformed from forest based to mining based one. Increasing collieries and colliery settlements increase the demand for drinking and domestic water. So in number. Tap water supply is also introduced. The significance of groundwater reserve thus increases due to better space perception of mining social group.

The second threshold in the mining area of the western Barddhaman is the initiation of underground mining in 1850. Action space extends below the surface. After dewatering, mine water is served to different sectors. It needs to be mentioned here that at every stage of mining the vegetal cover, another important component of hydrological cycle had to be removed. The destruction of forest leads to truncation of resource base of the forest based social group. Since 1970 environmental activists have become socio-politically strong. Now measures are being taken for resettlement of displaced communities who were once depressed and disposed of their right. Afforestation programmes are taken over subsided areas *paripasu* with deforestation.

Removal of solid (coal) and liquid (groundwater) leads to subsidence. Again seepage of groundwater very often leads to rushing of huge quantity of groundwater from one level to another level at high speed causing mine inundation and subsequent disruption in mining activity. These observations pose two very critical questions: Should we continue commoditisation of spatial resources at the expense of few social hazards or social hazards should be given more emphasis and therefore commoditisation should be stopped? This question is of global dimension in cases of extractive activities. However mine hazards can be avoided if proper measures are taken at right place on right time by the right people.

The discussion now ends with the model (Fig. 3) prepared by the author. The model is self explanatory, but certain terms need to be defined for better understanding of the model. The space inherited has been termed as actual space. The actual space is modified by human society to different actions and is referred to as action space. Social interaction of space may be termed 'simple' when nature of action is simple and social interaction is 'complex' when actual space is modified to increase intensity of one action or multiple actions. Society has been referred as 'simple' when social groups are local and demand is low and technology is less sophisticated and as 'complex' when an alien society (mining society) with sophisticated level of technology is superposed here.

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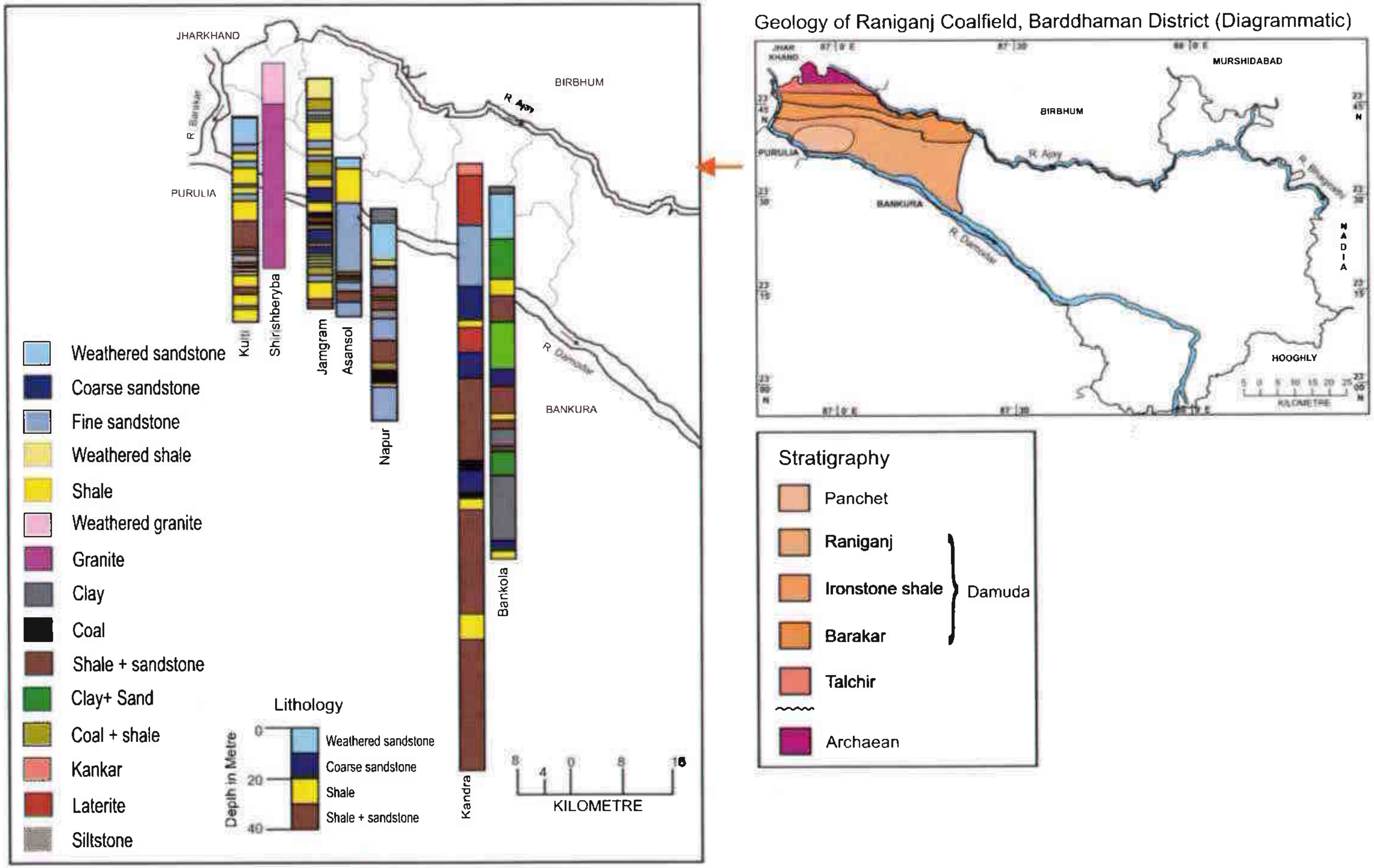
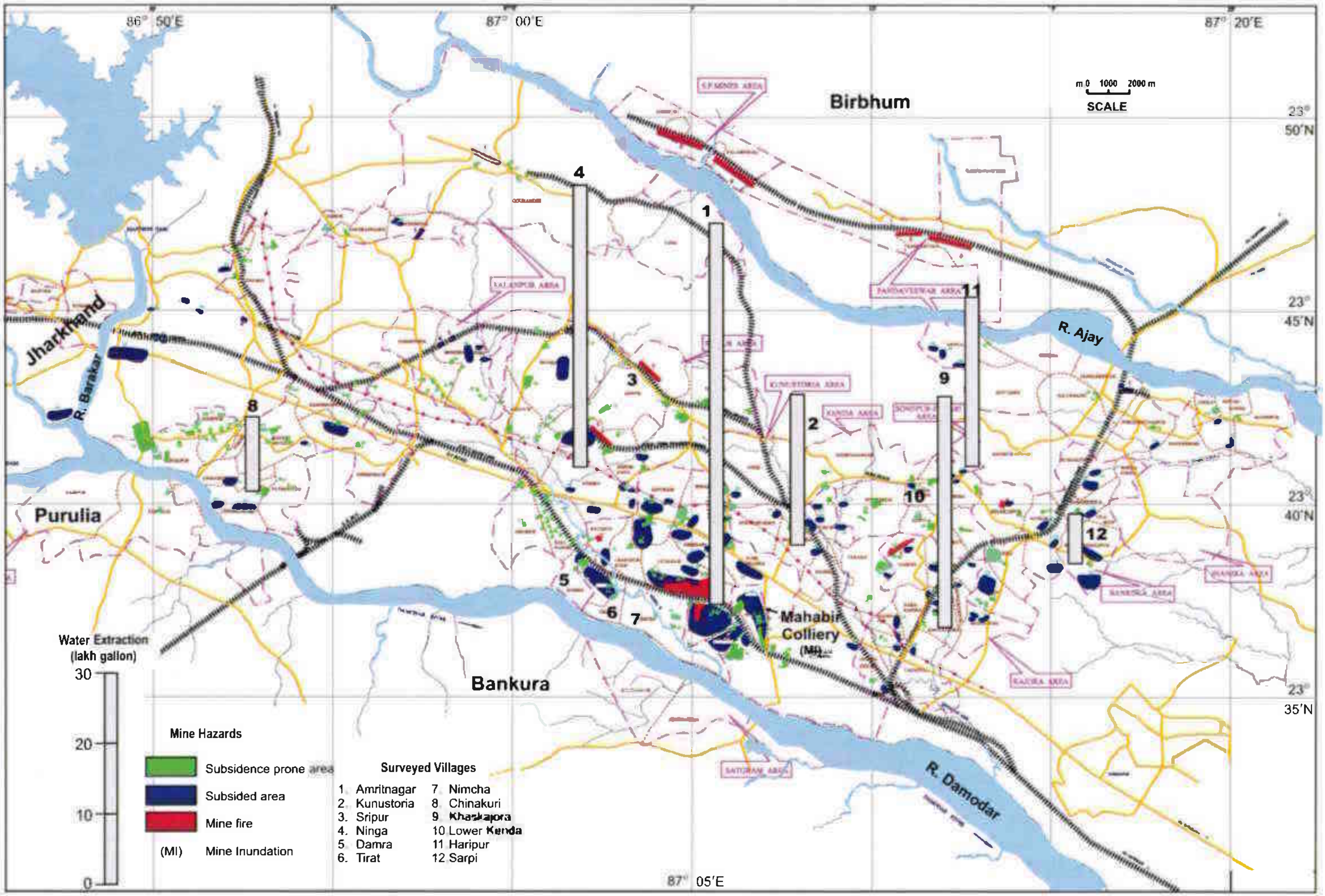
Dr. Mahamaya Laha
Assistant Professor of Geography
Netaji Mahavidyalaya,
Arambagh Hooghly, West Bengal
lahamahamaya@gmail.com

Fig. 1: Geology and Borehole Lithology of Raniganj Coalfield Area, Barddhaman district



Data Source: CGWB, Kolkata, 1998; Master Plan, Raniganj Coalfield, 1982.

Fig. 2: Dewatering and Mine hazards, Raniganj Coalfield, Barddhaman district



Based on Map of unstable locations in ECL (CMPDI, 2009) and Field Survey 2005, 2009.