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Research Needs for Sustainable Productivity in Mining and Mineral Based Industries in Odisha, India

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Abstract

The mining generates potentially high adverse impacts on air, water, land, noise, biological and socio-economic environment. The international agencies have given strong emphasis on regulatory framework and environmental impact assessment (EIA), occupational health and safety and the potential social and cultural implications of mine development. Poor quality of data/information becomes the major bottleneck in improving and strengthening the EIA reports which affects the environmental management programmes in and around mining areas. Therefore, there is strong need for improving the EIA reports in eliminating the shortcoming in EIA process. Reclamation of unproductive land arising due to mining activities need scientific approach and technology. The productive, economic and aesthetic value of the land can be restored by allocating enough resources and with continuous efforts. Reclamation programmes in developing countries through Scientific and demonstrative approaches are yet to take concrete shape although abandoned mines and waste areas need much attention in these countries compared to developed nations where the restoration guidelines and enactments are effectively implemented. Regular training and awareness programmes about existing Rules, Regulations and Guidelines relating to mining and environment and compliance are needed for all stakeholders on appraisal, monitoring and compliance including social linkage and impacts. Being the forests rich area, the Odisha region attracts various types of developmental activity with mining in the Centre and all these activities generate environmental pollutants or act as degrading environmental factors. The monitoring results of various mining projects in the Odisha region indicate that we need to put more effort in achieving satisfactory reclamation results by scientifically designing the rehabilitation programme. The ultimate objective is to return the land to its original land use system for sustainable productivity. Creating forest in mined out areas need the support of top soil, proper drainage and species selection which could match with the surrounding natural ecosystem and fulfill the need of wildlife and local human population. The present paper highlights one eco restoration technology demonstrated in Sukinda and Joda areas most similar to rehabilitation programme known in Japan as "Miyawaki Method". The present paper will discuss the results of a scientifically designed successful rehabilitation methodology for mining areas which acts as a sustainable technology for eco restoration of degraded lands. The technology is economical and can be easily replicated and implemented with the help of local resources. The success of this technology will change the ecological profile of degraded areas in these mining districts of Odisha state.

Keywords: Eco-Restoration • Native species • Mining • Vegetation • Dumps • Reclamation • Odisha

Introduction

The Constitution of India has assigned duties not to degrade the environmental resources and pollute the earth to ensure that future generation does not find the environment worthy of living and sustainable. The environmental issues are becoming so complex that we need to take integrated approach to address them. There are important legislations in India concerning environmental conservation, environmental pollution and forest and wild life protection. The Environment Impact Assessment (EIA) plays an effective role in attaining sustainable development goals and is widely used as a tool for project analysis. It is generally accepted that transparency in the process and recommendation by the experts and public to address the impacts help improving the EIA reports and therefore, EIA process has so improved globally that it has become an accepted tools which has removed over a period of time various shortcoming in EIA process. Poor quality of data/information was the major bottleneck in improving and strengthening the EIA reports. The Environmental Impact Assessment (EIA) Notification 1994 (MoEF, 1994) was first legal instrument making mandatory to a few categories of projects to carry out EIA and make Environmental Management Plan to address the adverse impacts. EIA Notification 2006(MoEF 2006) superseded the EIA Notification 1994 which now includes eight categories of projects (Table 1) to prepare EIA and EMP reports and obtain Environmental Clearance from Central Government in MoEFCC or State Environmental Impact Assessment Authority (SEIAA) [1-9].

Categories of projects			
Cat.	**Description**	**Sub-activities**	**Major projects**
1	Mining, extraction of natural resources and power generation	5	Major minerals, oil and gas, river valley, thermal power and nuclear projects
2	Primary processing	2	Coal washeries, mineral beneficiation

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3	Material production	2	Primary and secondary metallurgical units, sponge iron and cement plants
4	Material processing	6	Petroleum refining, coke oven, asbestos, leather processing,, soda ash
5	Manufacturing and fabrication	11	Fertilizers, pesticides, dyes and intermediates, drugs, distilleries, paint, paper and pulp, sugar, furnaces, furnaces
6	Service sectors	2	Oil and gas transportation, isolated storages
7	Physical infrastructure and environmental services	9	Air ports, ship breaking, industrial estates, TSDF, ports and harbor, roads, CETPS, municipal waste treatment plants, etc
8	Construction	2	Residential, commercial and townships

Table 1. Categories of projects attracting the provisions of EIA Notification 2006.

In a two stage process, the authority first stipulates the 'Terms of Reference' (TOR) for carrying out EIA studies to broadly ensure that impact study covers aspects of the environmental significance of the proposed area including biodiversity, endemicity and status of the flora and fauna of the area, importance of the ecosystem and socio economic impact. The public consultation is mandatory for certain projects to incorporate views on mostly local socioeconomic and environment concerns. Thereafter, EIA appraisal is done and Environment Clearance is issued. The category 1 and 3 as above are defined in Schedule of EIA Notification 2006 which includes all new projects or activities, expansion and modernization of existing projects or activities with addition of capacity beyond the limits specified for the concerned sector, and any change in product mix in an existing manufacturing unit beyond the specified range. In case of mineral based industries, the categorisation is in Table 2.

Project or Activity	**Category with threshold limit**		**Conditions if any**
	A	**B**	
1(a) (i) Mining of minerals	>100 ha of mining lease area in respect of non-coal mine lease. > 150 ha of mine lease area in respect of coal mine lease Asbestos mining irrespective of mining area	<100 ha of mining lease area in respect of non-coal mine lease < 150 Ha of mining lease area in respect of coal mine lease	*General Conditions shall apply except: (i) for project or activity of mining of minor minerals of Category 'B2' (up to 25ha of mining lease area); (ii) for project or activity of mining of minor minerals of Category 'B1' in case of cluster of mining lease area; and (iii) River bed mining projects on account of inter-state boundary. Note: (1) Mineral prospecting is exempted; (2) The prescribed procedure for environmental clearance for mining of minor minerals including cluster situation is given in Appendix XI;
1(a)(ii) Slurry Pipelines (coal lignite and other ores) passing through national parks/ sanctuaries/coral reefs, ecologically sensitive areas	All Projects		

1(b) Off-shore and onshore oil & gas exploration, development and production	All projects in respect of off-shore and onshore oil & gas development & production except exploration		**Note 1:** Seismic surveys which are part of Exploration Surveys are exempted provided the concession areas have got previous clearance for physical survey **Note 2:** All project in respect of off-shore and onshore oil and gas exploration are categorized as 'B2' projects"
3(a) Metallurgical industries (ferrous & non ferrous)	a)Primary metallurgical industry: All projects b) Sponge iron manufacturing ≥ 200TPD c)Secondary metallurgical processing industry All toxic and heavy metal producing units ≥ 20,000 tonnes /annum	Sponge iron manufacturing <200TPD Secondary metallurgical processing industry i.)All toxic and heavy metal producing units <20,000 tonnes / annum ii.)All other non –toxic secondary metallurgical processing industries >5000 tonnes/annum	General Condition shall apply for Sponge iron manufacturing Note: i. The recycling industrial units registered under HSM rules are exempted. ii. In case of secondary metallurgical processing industrial units, those projects involving operation of furnaces only such as induction and electric arc furnace, submerged arc furnace and cupola with capacity more than 30,000 tonnes would require environment clearance Plants/ units other than power plants (given against 1(d) of the schedule) based on municipal solid waste (non-hazardous) are exempted.

Table 2. Schedule of EIA Notification showing list of Projects or Activities of mining and metallurgical industries requiring Prior Environmental Clearance.

The rules framed under Environmental (Protection) Act 1986, specify standards of Air, Water and noise parameters for the projects to comply. The expansion and modernization components of projects will also require environmental clearance as per threshold. Prior Environmental Clearance (EC) process for Expansion or Modernization or Change of product mix in existing projects as per provision of para 7(ii) of the EIA Notification 2006 is given below.

(a) All applications seeking prior environmental clearance for expansion with increase in the production capacity beyond the capacity for which prior environmental clearance has been granted under this notification or with increase in either lease area or production capacity in the case of mining projects or for the modernisation of an existing unit with increase in the total production capacity beyond the threshold limit prescribed in the Schedule to this notification through change in process and or technology or involving a change in the product –mix shall be made in Form I and they shall be considered by the concerned Expert Appraisal Committee or State Level Expert Appraisal Committee within sixty days, who will decide on the due diligence necessary including preparation of Environment Impact Assessment and public consultations and the application shall be appraised accordingly for grant of environmental clearance.

(b) Any change in configuration of the plant from the environmental clearance conditions during execution of the project after detailed engineering shall be exempt from the requirement of environmental clearance, if there is no change in production and pollution load. The project proponent shall inform the Ministry of Environment, Forest and Climate Change/State Level Environment Impact Assessment Authority and the concerned State Pollution Control Board.

(c) Any change in product-mix, change in quantities within products or number of products in the same category for which environmental clearance has been granted shall be exempt from the requirement of prior environmental clearance provided that there is no change in the total capacity sanctioned in prior environmental clearance granted earlier under this notification and there is no increase in pollution load. The project proponent shall follow the procedure for obtaining No Increase in Pollution Load certificate from the concerned State Pollution Control Board as per the provisions given in Appendix –XIV.";

Case Report

Environmental concerns

During the environmental appraisal process, the experts suggest safeguard measures to the authorities to stipulate for compliance while according Environmental Clearance (EC). As stated above, completion of appraisal process leads to issue of EC to projects. The safeguards stipulated in EC of mining projects broadly cover the following:

Human resource development/Infrastructure

- An Environmental Management Cell should be set up in the project with at least one Nodal Officer of Environmental/Sciences background, to carry out the following functions:

(a) Formulation of action plan for management and control of environmental attributes e.g. air, water noise, solid waste and land degradation etc.

(b) Co-ordinate with agencies engaged in Environmental Monitoring and other related job.

(c) M maintains and updates records of the environmental attributes of the

project.

(d) Better interaction of Environmental Management Cell and liaison with various wings of the project as well as with State and Central statutory bodies.

Full-fledged laboratory with competent analysts to be established to avoid dependence on outside agencies for analysis of samples.

- Adequate funds should be made available for implementation of Environmental Management Plan and the implementation should be monitored regularly, funds allotted should not be diverted for any other purpose.
- The executives should be imparted training in Environmental Management aspects periodically.

Pollution control and resource conservation

- The effluents should be treated and reused/recycled. Waste water treated properly to meet industrial and agricultural requirements and possibly can be used for drinking and other purposes.
- Take suitable measures to prevent/mitigate leaching and dust emissions from the solid wastes generated. Technical and biological methods for proper utilization of solid wastes may be initiated.
- The water balance has to be prepared; identify and record the water sources (surface and ground both); the intake rate from each source and the quantity discharge for water resource planning and conservation.
- Provision for treatment of oil bearing effluents from the workshop.
- Enforce "Pollution under Control" Certificate for the vehicles.
- Sewage Treatment Plant to and treated water reused/recycled.
- Ensure use of protective devices by the workers in these areas.
- Action plan for phase wise plantation in the project area. Survey all the natural streams; water quality analysis to be carried out.
- Impervious pits for safe disposal and adopting safeguards for leaching in case of hazardous wastes and maximizing utilization
- Particle size analysis of the respirable dust sample to be carried out
- Blacktopping of roads to reduce the fugitive emissions. Work zone air quality monitoring

Ecological improvements

- Treated effluent water should be monitored to assess the status of biological diversity as the biological attributes are the best indicators of the quality of the aquatic environment.
- Degraded/disturbed area treatment plan made and implemented and environmental quality monitored.
- Assist in implementation of regional EMP.
- Plan of Conservation measures for protection of flora and fauna in the core and buffer zone to be drawn up. Plantation of plant species as green belt etc.

Socio-economic development

- Rehabilitation plan and community Development
- Take up works in peripheral villages for upliftment of local population with strict time schedule.
- Uploading soft copies of the half yearly progress reports on the website.

Para 10 ii and ii of EIA Notification makes it mandatory for the project to submit half-yearly compliance reports in respect of the stipulated prior environmental clearance terms and conditions in hard and soft copies to the regulatory authority concerned, on 1st June and 1st December of each calendar year and all such compliance reports shall be public documents. Copies of the same shall be given to any person on application to the concerned regulatory authority. The latest such compliance report shall also be displayed on the web site of the concerned regulatory authority.

The compliance achievement

The environmental quality in respect to ambient air, work zone and water quality in mining projects are not generally within the prescribed standards. Although, there are good efforts also in some projects in achieving the best quality of environment in and around the project, but out of boundary impacts is cause of concern. Several industries are EMS accredited but do not achieve national standards. Waste management is major area of concern. There are a few Suggestions for improvement in compliance:

1. Every project should have inbuilt infrastructure for environmental monitoring and equipped with adequate technical staff for effective environmental management.
2. The regulatory bodies like State Pollution Control Board, Central Pollution Control Board, should organize training/workshops in a year to impart necessary technical know-how as well as management practices with regard to environmental safeguards in the projects.
3. For mines located in in clusters, a cluster based approach may be adopted in implementation of environmental management plan.
4. Generally, the level of compliance to the conditions stipulated is not satisfactory in such projects who do not have adequate infrastructure and trained manpower to manage environmental safeguards.
5. "Corpus fund" is created by the projects and this fund should be specifically utilized for infrastructural development or peripheral development of project area.
6. To minimize the impact of pollution, carbon emissions budgeting may be carried out to know its intensity of release into the atmosphere due to developmental activity.
7. Certain organizations/Institutions of National repute may be identified to carry out specific work relating to Environmental management in projects.
8. In cluster areas, AAQ should be monitored by regulators and not individual projects and cost be borne by industries.
9. Regulatory authorities must ensure that solid wastes generated from mines and mineral based industries are utilized in local area road development after strict R and D recommendation.

Legal implication of non-compliance

Sustainability concept in any development process takes into account both the maintenance of environmental quality and economic development. The industrial development creates opportunities to achieve economic goals. However, the industrial activities can only sustain after duly incorporating the environmental management principles and implementing pollution control and abatement measures, resource conservation technologies and reducing out of boundary environmental impacts. The legislative tools help the industry to achieve excellence. The environment related legislations are getting stringent as the world is getting more and more industrialized and communities, the NGOs and Courts have also been aggressively involved in dealing with the environmental degradation problems and there are examples that industrial productivity has been affected due to several judgments. The interests of indigenous people and local communities have surfaced as prime factor affecting industrial production. Corporate Social Responsibility and appreciating the interest of the communities are the only ways to sustain productivity. A court case below highlights the judicial interpretation of environmental issues.

Court cases

1. In the matter of OA No. 1038/2018, The National Green Tribunal's

principal bench in Delhi on July 10 ordered the Central Pollution Control Board (CPCB), along with the state pollution control boards (SPCBs) to close 69 Polluted Industrial Areas (PIAs). The CPCB may make assessment of compensation to be recovered from the said polluting units for the period of last 5 years taking into account the cost of restoration and cost of damage to the public health and environment and the deterrence element. This categorisation was done on the basis of the Comprehensive Environmental Pollution Index (CEPI) and the areas were classified as Critically Polluted Areas (CPAs), Severely Polluted Areas (SPAs) and Other Polluted Areas (OPAs) which gives scores to industrial clusters based on the nature of pollutants, ambient pollutant concentrations, receptors (number of people affected) and additional high-risk elements. The industrial clusters with CEPI score more than 70 are CPAs, and between 60-70 as SPAs and below 60 as OPAs. It was ordered that no further industrial activities or expansion be allowed with regard to 'red' and 'orange' category units till the said areas are brought within the prescribed parameters or till carrying capacity of area is assessed and new units or expansion is found viable having regard to the carrying capacity of the area and environmental norms. Additionally, the tribunal said no activity or expansion will be allowed in these industrial clusters until these areas are brought within the prescribed parameters of environmental norms.

There is some very good development in controlling the pollution in industrial areas. Compared to CEPI areas of 2009-10, many clusters have now come out of CPAs in several states. However, new areas have come under CPA showing that environmental degradation in other areas continues and action needs to be taken. The new 38 CPAs and SPAs as identified by CPCB are given in Table 3.

State and Industrial clusters	CEPI	State and Industrial clusters	CEPI
Andhra Pradesh		Punjab	
Patancheru-Bollaram	75.42	Jalandhar	74.76
Assam		Ludhiana	73.48
Byrnihat	78.31	Rajasthan	
Chhattisgarh		Bhiwadi	79.63
Raipur	70.77	Jodhpur	81.16
Siltara ind area	79.94	Pali	80.48
Delhi		Sanganer ind area	79.10
Nazafgarh drain basin	92.65	Jaipur	77.40
Gujarat		Tamil Nadu	
Ankaleshwar	80.21	Vellore(N. Arcot)	79.38
Vapi	79.95	Mettur	71.82
Surat	76.43	Tirupur	72.39
Vatva	70.94	Manali	84.15
Rajkot	70.66	Uttar Pradesh	
Vadodara	89.09	Ghaziabad	72.30
Haryana		Kanpur	89.46
Panipat	83.54	Agra	76.22
Gurgram	85.15	Bulandsahar-Khurza	85.35
Karnataka		Varanasi-Mirzapur	85.35
KIADB Jigini Anekal	70.99	Firozabad	81.62
Peenya	78.12	Gajraula	80.14
Maharashtra		Mathura	91.10
Chandrapur	76.41	Moradabad	87.80
Tarapur	93.69	Uttarakhand	
		Udham Singh Nagar	81.26

Table 3. Critically Polluted Industrial clusters / areas with CEPI Scores >70.

The cluster area of Visakhapatnam, Dombivalli, Aurangabad, Korba, Navi Mumbai, Haldia, Howrah, Asansole, Angul Talchar, Ib valley, Jharsuguda, Ahmedabad, Bhavnagar, Mandi Gobind Garh, Junagarh, Cuddalore, Dhanbad, Coimbatore, Mangalore, Singrauli, Cochin, Noida, Indore, Faridabad have improved their score and have now out of designated CPAs. All the CEPI areas in the states of Kerala, Madhya Pradesh, West Bengal, Jharkhand, and Odisha have come out of critically polluted areas.

Disscussion

Regional and cumulative EIAs

Project level EIAs have many limitations to deal with certain kind of environment impacts. In our country, the development density is increasing very fast, as we have already identified 100 clusters in the country where pollution potentials have been assessed in terms of Comprehensive Environmental Pollution Index (CEPI). There are 38 areas where environmental degradation has reached now to a level that immediate intervention is needed and now in some clusters, developmental process has been halted for want of a Regional Environmental management Plan. Several mines and mineral based industries are operating in these CEPI areas. In such areas, we need to stress upon 'Cumulative impacts' rather than 'Individual Project Impacts'. Further, individual EIAs cannot address the impacts created by Ancillary industries. The impacts generated by these units sometime may exceed those of main projects. It also does not address or assess the cumulative impacts due to diverse and multiple developments in a geographical area. Smaller projects which are excluded from carrying out EIAs may collectively exert significant impacts. Therefore, Regional and Sectorial Environmental Assessments may be considered in such regions and EIA procedures may be applied to address the impacts generated by all development activities in a particular region other than specific projects. A regional or sectoral EIA may eliminate the requirement of project-specific EAs in a region or sector.

From the planning process to decisions making stage, REIA/SEIA offer better opportunities not only for analyzing existing policies, institutions and development plans in terms of environmental issues, but also become a tool for supporting environmentally sound sector-wide investment strategies. Thus, project-specific EIAs address the impacts on ambient air quality around the project but the regional or sectoral EIA will address the cumulative impacts like acid rain or other problems resulting from industrial developments in terms of their regional, national or even trans-national impacts.

The MoEFCC through its regional offices has been taking up environmental management issues in mining and other projects, through monitoring, interactions and workshop. The projects, regulators and RandD institutions

were meeting through this initiative during last few years. The gaps in technology, new research areas to be investigated and approaches to rational use and conservation of resources have been highlighted during these group interactions. The indicative list of recommendations for some development sectors is given below:

Bauxite and aluminum sector

- Removal of Silica from Bauxite (Bio-technology)
- Removal of Iron from Bauxite
- Development of Settler cum filter for separation of solids and liquor
- Recovery of Alfa Iron from Red mud
- Use of low grade bauxite for alumina production
- Manufacture of Al-Si Cement/Geo concrete from fly ash
- Treatment of spent pot lining
- Development of Insitu/surface gasification route
- Converting organic wastes (Anode butt) into power using ultra high temperature gasification
- Reduction of reactive silica in Bauxite before refining process.
- Reduce silica in liquor to increase alumina recovery and reduce scaling.
- Use of lime grit for cement and other usages
- Recovery of Gallium from Alumina Refinery liquor
- Recovery of alumina from red mud
- Use of red mud in iron manufacturing
- Use of red mud for corrugated sheets, tiles and cement manufacturing
- Removal of Titanium from Red mud
- Use of acidic flue gases-CO2, SO2, NOx for neutralization of red mud-helps in Carbon sequestration and hence a potential CDM project
- Reuse of red mud for geo-lining for waste fill sites.
- Bioremediation technology for neutralization of red mud.
- Economical and faster rehabilitation of exhausted mines for ecosystem restoration.

Exploration (CBM, OIL) and production

- Oil bearing sludge hazardous wastes could be raw material for cement industries.
- Incentives to industries for achieving greater carbon efficiency and promoting RandD.
- Awarding penalty as carbon tax specially for flaring beyond limits.
- Commission Oil Sludge Reduction Technologies for recovery of oil from oil sludge.
- Bioremediation of sludge after recovery of oil, will prove more cost effective and environmentally more acceptable.
- Demonstration or pilot scale R and D project to explore the possibility of storage or developing small power generating unit by utilizing excess flare gases.
- Energy balancing/thermal balancing/energy audit may be made part of environmental clearance conditions to help industries to identify wastes to enable them to take appropriate action for conservation and recovery.
- Use of Wax for promising industrial applications on the basis of R and D results.
- Top soil should be kept in active form with a grass cover or bushy cover to avoid nutrients moving away through run off and loss of soil carbon and should be utilized as early as possible.
- Comprehensive plan for decontamination of sites including taking up bioremediation work in hazardous waste sites.
- Identify the problem areas, which may be taken up by R and D institutions in project mode with full support from industries.
- Coordination among the Regulatory Authorities
- Need of a strong linkage between industries and institutions as a problem-solving group.
- Setting up of Coordination Committee for implementation of suggestions.

Another important aspect is neglecting the sub-grade resources and non-availability of exploring methods and technologies to utilize low grade minerals and converting wastes into useful products. Any effort in this direction will encourage both environmental protection and mineral conservation. RandD inputs in these fields are far meager and this calls for industries to come forward to achieve sustainable production by collaborating with experts and reputed institutions in all fields of environment and development and provide long term environmentally sustainable action oriented programmes to achieve the desired goals. Listed below are few recommendatory policy measures which can be considered for mining projects for amelioration of the environment and for checking further degradation:

Project level recommendations

- Collection of information on the vegetation structure of the forest ecosystem including species, and their phytosociological characteristics.
- Understanding of the population structure of species.
- Collection and analysis of information on regeneration status of species.
- To collect information on reproductive status of species-dead/harvested; mature/reproducing; Juvenile
- Collection and analysis of information on phenological characteristics of predominant species.

Recommendation for suitable management

- Site selection criteria should be strictly followed for establishing a particular project. The sensitive habitats like wet lands, reserve forests, migratory route of animal and birds, archeological sites, breeding grounds of organism and aquifers are a few parameters among other ecological considerations which are to be kept in mind.
- During various types of construction activities, top soil is removed. This fertile and life supporting entity should not be allowed to lose its vigour and character. Immediate utilisation of this soil for spreading on the infertile and recalcitrant solid wastes like OB dumps and other materials and for taking up plantation should be planned to derive long term ecological benefits.
- The workers engaged in various activities and the local people should be educated and made aware of the importance of nearby natural habitats. The project authorities, contractors and other persons having work force should arrange fuel wood/other fuel facilities for the labourers. The protected surroundings will provide a lot of benefits to the project and the society and will help controlling air, water and noise pollution.
- The Project areas should be surveyed and suitable landscape developed. The indigenous varieties of forest and other trees and herbaceous species should be encouraged to be planted in project

area as well as in nearby village/town areas.

- The site for schools and hospitals should be so chosen that the air and noise limits as prescribed for sensitive areas can be achieved easily. The project activity should be separated by thick green belt from these areas to avoid noise and air impacts reaching the sensitive areas.
- In India, all types of projects including infrastructure projects generally are required to rehabilitate the population on whose house/land the project operations start. This is a very sensitive aspect. It is better to take up this issue on priority and comply within a specific time schedule to avoid any resentment, grievance and various other types of social problems. There are instances that project viability comes at stake due to rehabilitation and resettlement issues.
- The drilling machines to be fitted with dust collection, suppression and disposal arrangements; water sprinkling of drilling zones by deep wetting. Blasting should be exercised with wet conditions only and with properly wetting the blasting site. Regular maintenance of HEMM and other transport vehicles, control of speed limit and smoke emission. Roads to be blacktopped, well maintained and sprinkled with water.
- Mine spoil to be reclaimed by either engineering or biological reclamation methods. Leaching of any water from dumps to be routed through garland drain and treated in a settlement tanks before final discharge. Mine discharge water should also be handled with proper treatment before discharging into natural water course.
- Environmental Management Cell to be created with clear-cut responsibility assigned to respective officers of the cell. Collection and updating of data to be done regularly throughout the Project operation cycle. Yearly Action Plan is required to be made for management and control of all the environmental components.
- Adequate fund provision must be made for implementing the programmes relating to environmental management in the project area and in no case, the funds should become a limiting factor. The sooner the environmental problem is ameliorated, the lesser the investment is needed from the Project and vice-versa.

Regular training and awareness programmes about existing Rules, Regulations and Guidelines relating to mining and environment and compliance should be given to the officers at all levels right from Head of department to the field level officers of mining, environment and forests departments. Heads of organisations of the mining projects must know about the environmental action plans and their achievements. At least quarterly meetings should be taken by him to review the progress and to direct the concerned accordingly. This helps to execute the project at desired speed and target

Reclamation and ecological management

The mining generates potentially high, adverse impacts on air, water, land, noise, biological and socio-economic environment. Reclamation of unproductive land due to mining and the wastes arising due to mining activities need scientific approach and technology. The productive, economic and aesthetic value of the land can be restored by allocating enough resources and with continuous efforts. Reclamation programmes in developing countries through Scientific and demonstrative approaches are yet to take concrete shape although abandoned mines and waste areas need much attention in these countries compared to developed nations where the guidelines and enactments are effectively implemented for restoration of derelict lands. The Surface Mining Control and Reclamation Act, 1977 in USA which has various provisions concerning reclamation and restoration of coal mining areas, emphasize on RandD aspects and make these as legally binding components of the Act. The following provisions of the above Act are listed below concerning mine reclamation and management:

- Surface mining operations are not conducted where reclamation as required by this Act is not feasible.
- Surface coal mining operations are so conducted so as to protect the environment.
- Undertake to reclaim surface areas as contemporaneously as possible with the surface coal mining operations.
- Strike a balance between protection of the environment and agricultural productivity and the Nation's need for coal as an essential source of energy
- Promote the reclamation of mined areas left without adequate reclamation and which continue to substantially degrade the quality of the environment
- Stimulate, sponsor, and provide for research investigations, experiments, and demonstrations, in the exploration, extraction, processing, development and production of minerals and the training of mineral engineers and scientists in the field of mining, minerals resources and technology, and establishment of research and training centers.
- Consult with other agencies having expertise in the control and reclamation of surface mining operations and assist States, local governments, and other eligible agencies in the coordination of such programs;
- Develop and maintain and Data Center on Surface Coal Mining, Reclamation and Surface Impacts of Underground mining, for land use planning and surface and underground mining and reclamation operations;
- Monitor underground and surface mining and reclamation techniques directed at eliminating adverse environmental and social impacts.

Abandoned mine reclamation fund has been created under the above Act which can be used for reclamation and restoration of land and water resources adversely affected by mining, including reclamation and restoration of abandoned surface mine areas, abandoned coal processing areas, and abandoned coal refuse disposal areas; sealing and filling abandoned deep mine entries and voids; planting of land adversely affected by past coal mining to prevent erosion and sedimentation, prevention, abatement, treatment and control of water pollution created by coal mine drainage including restoration of stream beds and construction and operation of water treatment plants; prevention, abatement and control of burning. These provisions include:

- Enforcement and collection of the reclamation fee; all operators to pay a reclamation fee. Any portion of the reclamation fee not properly or promptly paid shall be recoverable, with statutory interest.
- Studies, research and demonstration projects.
- Restoration, reclamation, abatement, control or prevention of adverse effects of mining.
- Grants to the States to implement such programmes.
- Any person, making false statement, representation or certification, shall, upon conviction, be punished by a fine of not more than $ 10,000, or by imprisonment for not more than one year, or both.
- From coal mine operators, in any court of competent jurisdiction in any action at law to compel payment of debts.
- Each state may submit a State Reclamation Plan and annual projects to carry out abandoned mine reclamation.
- Reclamation Plan shall identify the areas to be reclaimed, the purposes for which the reclamation is proposed, the relationship of the lands to be reclaimed and the proposed reclamation to surrounding areas, the specific criteria for ranking and identifying projects to be funded, and the legal authority and programmatic capability to perform such work.

In India, explicit provisions on reclamation/management are needed and the provisions have to be made effective in rehabilitation of mining areas. Old mining areas in Jharia and Raniganj are still to be addressed through management plans for suitable reclamation. Reclamation programmes for other minerals also are not satisfactory. The reclamation in stone and lime stone quarries and small metal mines is very poor. The overburden reclamation programmes in the mining projects suffer due to absence of application of appropriate technology and mitigative measures considering the slope stability, run off control, leaching, species suitability, engineering design manipulation at top layer of overburden and long term programme for protection and management. Grossly insufficient fund allocation has resulted into very low success in the programme. There is need to have some effective RandD support mechanism duly complemented by legislative provisions like in U.S.A. so that resource availability and technical support are in place for reclamation of mined out areas.

Being the forests rich area, the Odisha region attracts various types of developmental activity with mining in the Centre and all these activities generate environmental pollutants or act as degrading environmental factors. The compensatory plantation, pollution control measures, environment management plan etc. take time to restore the damage caused to the eco system. Hence the pace of development should be sustainable to environment. The legislative requirement in our country has emphasized through various regulatory tools like environmental clearance, for the projects to have strong environmental infrastructure along with equipment and human support base for assessment, monitoring and evaluation of environmental impacts arising due to project activities. Present State of ecosystem services in Odisha is fast changing. Rapid expansion of the industrial sector has led to increase in extraction of minerals which occur in mostly the forested regions. Role of the forests is also important in maintenance of ecological balance. Long term strategy on forest conservation vis-à-vis mining activities is needed with an objective to assess the extent of change in forest cover which can be ecologically permitted for developmental activities. A study was done in mineral rich states of Odisha, Jharkhand, Madhya Pradesh and Chhattisgarh by the Forest Survey of India and Indian Bureau of Mines (IBM), Nagpur which reveal that a total of 353 leases occupy an area of 90,695 ha having forest cover 53,217 ha out of which 71% is dense forest and 29% is open forest. There has been rise in human-animal conflict in these regions. Therefore, there is need to address biodiversity issues in these areas especially the afforestation programmes which mostly emphasize on either exotic or low ecological value plant species(Upadhyay and Debata,2020). These efforts do not really help in plugging the fragmentation of habitat. Taking up plantation of local species with good ecological value will help maintaining the ecological balance and food chain. Local species provide social and economic values to the human society.

The Eco-Restoration approach

In the eastern region of the country rich in minerals, a large number of Opencast and underground mining projects are under operation and new development projects in various areas are being proposed. The environmental implications of open pit mining are much more significant in cluster areas as these generate high level of cumulative impact on land and affect environmental settings. However this method is comparatively safe, easy and economically better process of extraction. The eastern region is expected to attract more projects as demand for these minerals has been rising. The Odisha is witnessing industrial development much faster, for example, with large Chromite, Iron and Coal reserves may encourage setting up of more Ferro chrome and Steel Industries and Thermal Power Plants, respectively.

Odisha State produces 36.26% and 99.8%, respectively, of Iron and Chromite ore of the total production in India. Iron and Chromite ore opencast mines create huge burden of solid wastes like top and sub soil, over burden and inter burden, tailing from ore processing and wastes containing sub-grade minerals and the pollution potential of non-reclaimed wastes are very high. The loss of biodiversity is also one of the major issues as over 60-70% of the lease area in Keonjhar and Sundergarh districts is located on forest land (CPCB, 2007). In the mining leases of Keonjhar, Sundergarh and Mayurbhanj districts of Odisha almost 14% of the total lease area is degraded.

While according the environmental clearance, the Ministry of Environment and Forests to mining projects stipulates for reclamation and revegetation of mining degraded areas to ensure successful rehabilitation:

1. Proper stacking of top soil with proper slope at designated area for use in reclamation and rehabilitation of mined out areas.
2. Proper dumping of overburden material with height of dump not to exceed 30 meter (sometimes 10-15 meter) with overall slope below 28 degree; catch drains and siltation ponds to arrest silt and sediment flow; garland drain leading to sump and separate storm water drainage system; retaining wall at the toe of OB dump and proper treatment of discharged water from mining areas.
3. Back filling of the mined out areas and reclamation by plantation/ afforestation.
4. Submission of detailed mine decommissioning plan.
5. Green belt and plantation in external OB and backfilled areas by native species.

There is strong need to put more effort in achieving satisfactory reclamation results in mining projects by scientifically designing the rehabilitation programme. For sustainable productivity, the ultimate objective is to return the land to its near original land use. The factors like top soil, proper drainage and species selection which could match with the surrounding natural ecosystem and fulfil the need of wildlife and local human population are important factors for creating afforestation in mined out areas. The co-author of this paper, Dr. V.P Upadhyay developed demonstration plots in a few mining project area as an example of recreating the original land use i.e. natural ecosystem by bringing back potential natural species of the area and enhancing the quality of ecological services. Demonstration projects were planned in Iron ore and Chromite Ore mining belts of Odisha for reclamation of degraded lands. With initial briefing and discussions with the mining projects, it was decided to implement the reclamation programme on Over Burden dumps of a few opencast mining projects. For establishing a demonstration plot and for scientific reclamation of waste areas in mining projects, following guidelines were made:

- Ensure sufficient quantity of seedlings depending on the size of the plot selected for reclamation.
- All the seedling species will be of local natural origin.
- Plantation will be done @2-3 seedlings/M2
- Ensure involving local community in the plantation work.
- Availability of land with both flat topography and with height and slope will be acceptable.
- Availability of top soil to spread on the land with at least 20-30 centimeter thickness. Top soil may be mixed with sub soil in case sufficient quantity of top soil is not available. But top soil spreading is prime requirement for this experiment.
- Mulching material to spread on the surface of the soil after planting the seedlings will be rice straw, availability of which may be ensured. The spreading of straw will be very thick and dense. The sufficient quantity of rice straw may be ensured.
- If the degraded land is OB dump or any land with height and slope, the same will be subjected to treatment to ensure that there is no sliding of soil and silt loss. The whole area will be divided into 5 meter segments vertically and bamboo stumps will be inserted (1 meter below the surface and half meter above the surface) on boundary of each segment horizontally. All the stumps will be connected with sliced bamboo plates by weaving like carpet. For flat surface this

system may not be needed.

- The experiment will require 1-2 year old seedlings of the local species. The seedling density will be 2-3 seedling/m2. As per the size of the plot, quantity of seedlings may be ensured. Number of species should be as many species as we can collect from the nurseries. This means biological diversity in the experimental plot should be aimed at 'Very High'.
- The planting of seedlings may be done with the help of communities and school children of the locality. Before involving them we will have to arrange an environmental awareness/training programme for them about the scheme.
- No digging or trench is needed for planting the seedlings. The seedlings will be panted within 60 centimeters of the surface of the soil and the size of the pit will be just little more than size of the seedling pot.
- A small water container/pool may be needed for submerging the seedling pot into the water before removing the seedling from the pot and planting in the field (Table 4).

Sl. No.	Location	Name of Project
1.	Village(S) Soyabali & Balita, Tehsil Barbil, District Keonjhar	Thakurani Iron Ore Mining Project of M/s Sarda Mines Pvt. Ltd.
2.	Iron ore mine, Joda, Keonjhar	Essel mining
2.	Sukinda, Jajpur District	Chromite Mines of M/s IMFA Ltd.
3.	Sukinda, Jajpur District	Chromite Mines of M/s Balasore (Ispat) Alloys Ltd.
4.	Sukinda , Jajpur District	Chromite Mines of M/s Tata Steel Ltd.
5.	Village Kamarda, Balipada & Tailangi, Tehsil Sukinda, District Jajpur,	Chromite Mining Project By M/s B. C. Mohanty & Sons Pvt. Ltd.

Table 4. locations inside the mining projects.

To find out the potential local indigenous natural species of the area, vegetation study results of Environmental Impact Assessment reports of the projects were used for selecting species for planting. The projects selected the nursery plants from the list provided to them. The site preparation and procurement of materials was done between February and June, 2011 and plantation programme was undertaken between July and September, 2011. The list of the species recommended for both the regions is given in Table-5.

Sl. No.	Botanical Name	Common Name	Family
1.	*Acacia arabica wild.*	Babul	Fabaceae
2.	*Acacia catechu*	Khaira	Fabaceae
3.	*Adina cordifolia*	Kurum	Rubiaceae
4.	*Aegle marmelos*	Bel	Rutaceae
5.	*Albizia lebbeck (l.) benth.*	Kala siris	Fabaceae
6.	*Albizia procera*	Khir	Fabaceae
7.	*Anogeissus latifolia (d.c.) wall*	Dhoura/Dhamoda	Combretaceae
8.	*Anthocephalus cadamba niq.*	Kadamba	Rubiaceae
9.	*Artocarpus heterophyllus lamk.*	Kathal/Jack fruit	Moraceae
10.	*Azadirachta indica a.*	Neem/Margosa tree	Meliaceae
11.	*Bauhinia retusa*	Kanchana	Fabaceae
12.	*Bombax ceiba*	Simuli	Bombacaceae
13.	*Bambusa tudla*	Bamboo	Poaceae
14.	*Bridelia retusa*	Kasi	Euphorbiaceae
15.	*Buchanania lazen*	Chara	Anacardiaceae
16.	*Butea frondosa (lamk.)*	Palas	Papilionaceae
17.	*Butea monosperma*	polash	Fabaceae
18.	*Carya arborea*	Kumbhi	Juglandaceae
19.	*Cassia fistula*	Sunari	Fabaceae
20.	*Chloroxylon swietenia*	Bheru	Rutaceae
21.	*Cleistanthus collinus*	Karada	Phyllanthaceae
22.	*Crataeva religiosa*	Baruna	Capparaceae
23.	*Dalbergia sissoo (roxb.)*	Shisham	Fabaceae
24.	*Ficus glomerata*	Dimri (Gular)	Moraceae
25.	*Dendrocalamus strictus*	Bauns	Poaceae
26.	*Diospyros melanoxylon (roxb.)*	Tendu/Kendu	Ebenaceae
27.	*Emblica officinalis*	Amla	Phyllanthaceae
28.	*Erythrina indica lamk.*	Paldhua, Rakta madar	Fabaceae
29.	*Ficus bebghalensis (linn.)*	Bargad/Banyan	Moraceae
30.	*Ficus religiosa linn.*	Peepal/Bo tree	Moraceae
31.	*Gardenia turgida*	Kuruda	Rubiaceae
32.	*Gmelina arborea (roxb.)*	Gamhar	Verbenaceae
33.	*Grewia tillaefolia*	Dhaman	Malvaceae
34.	*Holarrhena antedysenterica*	Kurei	Apocynaceae
35.	*Lagerstroemia parvillora*	Sidha	Lythraceae
36.	*Lannea coromondelica*	Mai	Anacardiaceae
37.	*Madhuca indica j.f. gmel.*	Mahua	Sapotaceae
38.	*Madhuca longifolia*	Mahula	Sapotaceaa

39.	*Melia azadirach*	Meetha Neem	Meliaceae
40.	*Mangifera indica l.*	Mango/Aam	Anacardiaceae
41.	*Mitragyna parviflora*	Kuruma	Rubiaceae
42.	*Phoenix sylvestris*	Khajuri	Arecaceae
43.	*Pongamia glabara vent.*	Karanj	Papilionaceae
44.	*Pongamia pinnata*	Karanja	Fabaceae
45.	*Pterocarpus marsupium roxb.*	Piasal	Fabaceae
46.	*Pterospermum acerifolium*	Muchkund	Sterculiaceae
47.	*Saraca asoca*	Ashok	Fabaceae
48.	*Schleichera oleosa*	Kusuma	Sapindaceae
49.	*Semecarpus anacardium*	Bhalia	Anacardiaceae
50.	*Shorea robusta gaertn. f*	Teak/Sagwan	Verbenaceae
51.	*Syzigium cumini (l.)*	Jamun/Java plum	Myrtaceae
52.	*Tectona grandis l.f.*	Teak/Sagwan	Verbenaceae
53.	*Tamarindus indica*	Imli/Tentuli	Fabaceae
54.	*Terminalia arjuna*	Arjna	Combretaceae
55.	*Terminalia bellerica (gaertn.) robx.*	Bahera/Bastard	Combretaceae
56.	*Terminalia chebula*	Harida	Combretaceae
57.	*Terminalia tomentosa wt. & arn.*	Asan/Black murdah	Combretaceae
58.	*Woodforida fruticosa*	Dhatki	Lythraceae

Table 5. List of potential natural species for rehabilitation of degraded lands.

We aimed at developing these demonstration plots to act as AWARENESS CUM TRANING GROUNDS for all other projects located in iron ore and chromite ore belts of the State of Odisha [Figure 1-6]. The success of these experiments will help broadening the scope of rehabilitation of the waste dumps and mined out areas. Plantation of local species will help reducing the fragmentation of habitats and restoring the natural species of flora and fauna of the area. Post-mining reclamation programmes will certainly use these technologies to restore these damaged habitats to near natural condition.

The Use of top soil which preserves natural germ plasm as seed bank and also keeps organic matter alive due to microbial turnover is most important component of restoration, therefore, must be utilized early. If top soil cannot be utilized concurrently, it should be stored separately for future use. The overburden, waste rock, rejects and fines generated during prospecting and mining operations or tailings, slimes and fines produced during sizing, sorting and beneficiation or metallurgical operations should be separately stored at sites impervious ground to ensure minimum leaching due to precipitation and managed properly so as not to cause degradation of environment. The waste rock, overburden, etc. shall be back-filled into the mine excavations with a view to restoring the land to its original land use as far as possible. The external waste dumps need to be suitably terraced and stabilized and reclaimed.

A few photographs of the sites [Figures 1-6] indicate that in course of time these natural juvenile species started reproducing and converting these human modified habitats to natural habitats. The experiment was done as strip and block plantation in both areas i.e. having gentle topography and with moderate to steep slopes. The diameter at base of seedling and height were being measured by tagging 5-10 individuals each species from 2011 to 2016. However, at one of the sites (IMFA Chromite mine) due to heavy rain (23.5 cm) in one day in October, 2011, the seedling plots were damaged and mass of soil slided to the base of the slope. Re-working in these areas was done. The Balasore Alloy's Eco restoration area was converted to mineral functioning area, hence no further results.

Figure 1. The Mining sites of reclamation with community approach at Sarda Iron Ore Mines Joda, Keonjhar, Odisha,India

Figure 2. The eco-restoration of mining dump of Iron Mining siteat Essel Iron Ore Mines Joda, Keonjhar, Odisha, India

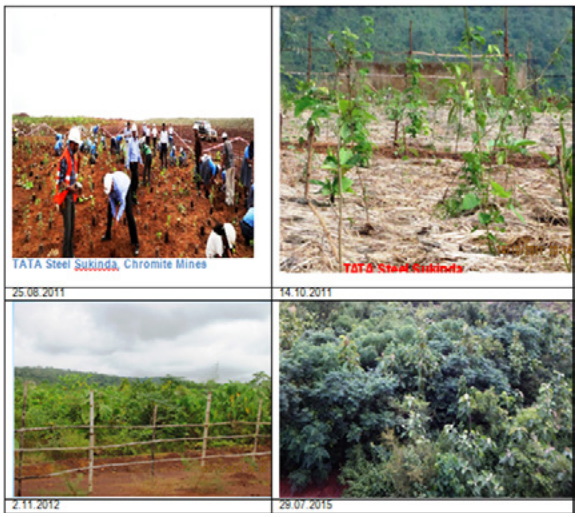

Figure 3. The eco-restoration of mining dump of Chromite Mining site at Tata steel Sukinda Chromite Ore Mine Sukinda, Jajpur , Odisha, India

Figure 4. The eco-restoration of mining dump of Chromite Mining site at Balasore Alloy Limited, Sukinda Chromite Ore Mines, Sukinda, Jajpur , Odisha, India

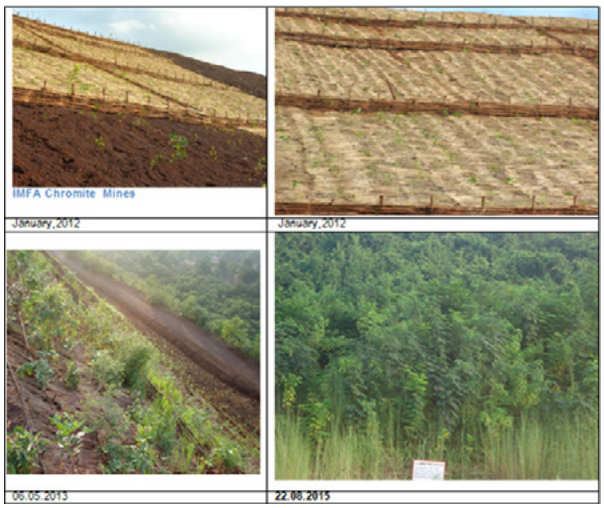

Figure 5. The eco-restoration of mining slope dump of Chromite Mining site at IMFA Sukinda Chromite Ore Mines Sukinda, Jajpur , Odisha, India

Figure 6. The eco-restoration of mining dump of Chromite Mining site at BC Mohanty Sukinda Chromite Ore Mines, Sukinda, Jajpur , Odisha, India

Conclusion

The experiment shows that native plant species should be given importance in reclamation. The EIA should cover primary assessment data/information on the basis of field visit. The ecological structural parameters should be collected by following standard methods applicable to plants and animals and should be described in EIA report to ensure the soundness of data. The assessment of lower forms of biodiversity is generally not given much importance during EIA study. These groups of plants and animals act as indicator of ecosystem health. The quantitative data on lower group of Angiosperms and Gymnosperms and Pteridophytes, Bryophytes, Algae and Fungi as a rapid survey information must be provided in the report. The wildlife assessment (animals, birds etc.) should as far as possible be done as a primary survey on representative locations. From these survey reports, we make our basis for selection of species to be planted which are acceptable to ecosystem. Using the top soil of mining areas help preserving the gene pool of the plants and animals from where they can regenerate/ reproduce to ensure availability of their population in surroundings.

As most of the mining areas generally contain good forest cover, the mining projects may have greater impact on flora and fauna of the area as with increase in mining activity, forest areas will go on decreasing. We discourage planting exotic species as we do not know their ecological impacts which may change the micro ecological settings. The potential natural species/Indigenous species on the other hand shall generate long term environmental benefit in terms of biodiversity conservation and socio-economic acceptance. We have found that species survival is more than 90% across all sites. The experimental areas have now the self-sustaining species with new generation of trees established at site with regeneration. The impacts of mining in using agricultural land will result in shrinkage in crops areas and net crop yield, increase in population flux with greater demand of agriculture produce. It is likely that there may be conflicts between local inhabitants and Project authorities. To meet the local needs, especially the food, the mining projects should adopt peripheral villages to introduce new socioeconomic and agricultural initiatives. All degraded mining areas may be restored with native species to attain the character of sustainable ecosystem. The eco-restoration approach described in this paper is, therefore, recommended for environmental management of degraded mining habitats.

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