**PROJECT REPORT ON**

# DEVELOPING ECOLOGICAL RESTORATION MODEL IN THE MINE SPOILS AT TETULMARI UNDER SIJUA AREA (ABOUT 8-10 Ha) OF BCCL MINE

**Submitted To**

**Bharat Coking Coal Limited (BCCL)**

**By**


**Forest Ecology & Environment Division**
**Forest Research Institute**
**Dehradun-Uttarakhand**


**2015**

# PROJECT PROFILE

**Project** : **Developing Ecological Restoration Model in the Mine Spoils at Tetulmari under Sijua Area (About 8-10 ha) of BCCL Mine**

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3. **Date of commencement of the project** : July 2011

4. **Date of the completion of the project** : July 2014

5. **Total Budget of the project**: 20.0 Lakhs

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# Preface

Coal is a most important and abundant fossil fuel having a proven reserve of 860 billion tons, out of which 55% of it is being utilized in meeting country's energy demand. The power sector followed by iron, steel and cement segments are the largest consumer of coal in India. Thus, it becomes inevitable for continuous mining of coal. Several environmental consequences such as deforestation, release of toxic and heavy metals into soil, noise, air and water pollution and alteration of healthy environment are well associated with the mining activities. These ill effects persist for many years resulting abrupt changes in natural environment. Thus, protection of environment degraded due to mining, becomes indispensable part of our mining culture. Neither mining nor the conservation of environment can be ignored and sidelined. For a sustainable growth of our country a clear cut balance need to be worked out. Ecological restoration provides a solution for sustainable management of resources and environmental protection in mining industry.

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# Executive summary

Almost all the mining techniques from mineral explorations to production and transport are causing environmental damage in several ways. The list includes deforestation, loss of top soil, accelerated soil erosion, soil contamination, qualitative and quantitative depletion of surface and ground water resources, migration of wild life and avian fauna, and addition of air pollutants and dust in the atmosphere. Land degradation, disruption in the goods and services offered by the nature and forest has been compromised greatly. In lieu of this, to reverse the degradation of environment in Dhanbad coalfield, a model plantation/ecological restoration was carried with the objectives i) To stabilize overburden dumps to control erosion; ii) To conserve and enhance the biodiversity of mined out areas; iii) To generate natural resources to cater the needs of local people and iv) To develop aesthetic view of mined out area. Based on the condition of area, different ecological restoration approaches were applied during project period of three years (2011- 2014). A total of 13,000 plants of different species including horticulture species have been planted in the project site.

Various measures such as direct seeding, seed mixed soil ball, seedling planting, stem cutting, bulbils, culms/slips planting were used for multiplication of species depending on their propagation behavior. The tree species included *Albizia lebbeck, Albizia procera, Bauhinia variegata, Dalbergia sissoo, Cassia fistula, Madhuca indica, Pongamia pinnata, Terminalia arjuna* (forestry species); *Aegle marmelos, Artocarpus heterophyllus, Mangifera indica, Psidium guajava, Phyllanthus emblica, Syzygium cumini and Zizyphus* spp. (horticultural species); *Vitex negundo, Azadirachta indica, Asparagus racemosus, Rauvolfia serpentina* (medicinal plants) and *Cenchrus ciliaris, Pennisetum purpureum, Panicum maximum, Arundo donax, Pennisetum pedicellatum* (grasses). The restoration approach applied have been found to be very successful in enriching the diversity of trees, shrubs, herbs and grasses in the project site. After a period of three years of restoration, the site has been converted into dense diverse vegetation cover and is able to cater the needs of fodder resource to the local communities.

## INTRODUCTION

Coal has relatively high importance for the economical growth of a country. The Mining industry in India is a major economic activity which contributes significantly to the economy of country. The GDP contribution of the mining industry varies from 2.2% to 2.5% only but going by the GDP of the total industrial sector it contributes around 10% to 11%. Even mining done on small scale contributes 6% to the entire cost of mineral production. Indian mining industry provides job opportunities to around 700,000 individuals. India is the largest producer of sheet mica, it ranks 3rd in production of coal, iron ore and lignite, 2nd in barites, 4th in iron ore, 5th in bauxite and crude steel, 7th in manganese ore and 8th in aluminum. Mining in India depends on over 3,100 mines, out of which over 550 are fuels mines, over 560 are metals, and over 1970 are extracted for nonmetals. About 600 coal mines, 35 oil projects and 6,000 metalliferous mines of different sizes employing over one million persons on a daily average basis. Unless controlled by other departments of the Government of India mineral resources of the country are surveyed by the Indian Ministry of Mines.

The minerals in India are an important source for earning foreign exchange as well as satisfying domestic needs. India exports iron ore, titanium, manganese, bauxite, granite, and imports cobalt, mercury, graphite etc. India accounts for 12% of the world's known and economically available thorium and is the world's largest producer and exporter of mica, accounting for almost 60 percent of the net mica production in the world. India also has one of the largest deposits of manganese in the world, and is a leading producer as well as exporter of manganese ore.

Mining causes the destruction of natural ecosystems through removal of soil and vegetation and burial beneath waste disposal sites. The restoration of mined land in practice can largely be considered as ecosystem reconstruction and restore the capability of the land to capture and retain fundamental resources. In ecological restoration planning, it is imperative that goals, objectives, and success criteria are clearly established to allow the restoration to be undertaken in a systematic way, while realizing that these may require some modification later in light of the direction of the restoration succession. Even though ecological theory lacks general laws with universal applicability at the ecosystem level of organization, ecological knowledge does have high heuristic power and applicability to site-specific ecological restoration goals. However, monitoring and management are essential, as the uncertainties in restoration planning can never be overcome. The concept of adaptive management and the notion that a restored site be regarded as a long-term experiment is a sensible perspective. Ecological restoration

includes the management of all types of physical, chemical and biological disturbances of soils such as soil pH, fertility, microbial community and various soil nutrient cycles that makes the degraded land into productive one.

The productive ecosystem becomes a source of livelihood to the dependent population through providing tangible (fuel, fodder, timber, medicine) and intangible (purifying air and water, detoxifying and decomposition of wastes, regulation of climate, regeneration of soil fertility and pollination of crops) benefits.

Traditional management of ecological systems focuses on products or services desired by people, with emphasis on marketable commodities. Resource managers learn just enough about ecosystems to maximize the production of these commodities. As a result, ecosystems are overused and poorly understood. A different perspective and approach to ecosystem management is required. Resource managers have begun to appreciate the relationship between an ecosystem's condition and its sustainability for human use. Some studies suggest that regional ecosystem degradation can lead to a decline in production of natural resource commodities. Evidence of widespread ecosystem decline is seen in the growing number of threatened plant and animal species worldwide. Decline is defined as reduced species, and collapse in ecosystem structure, functions and processes.

Ideally, ecological restoration should work on mosaics of ecosystems and ecotones over large landscapes, while at the same time paying close attention to localized species populations, isolated habitats, and the small levels of ecological organization.

## ECOLOGICAL RESTORATION

A variety of approaches can be used to overcome different forms of degradation. In some cases the objective is to restore the original ecosystem and recover the former biodiversity, in others the aim is simply to use the site for some productive purpose such as agriculture. It is also defined as the replication of a site condition prior to disturbance.

It is the scientific study supporting the practice of ecological restoration which is the practice of the renewing and restoration the degraded, damaged, or destroyed systems and habitats in the environment by the active human intervention and action. The term “restoration ecology” is therefore

commonly used for the academic study of the process, whereas the term “Ecological restoration” is mainly used for the actual project or process by restoration practitioners.

Ecological restoration is defined as “the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed”(SER, 2004). It is a practical management strategy that requires extensive knowledge of the biotic and abiotic environments that sustain biological communities, ecosystem processes, full understanding of the ecological deficiencies in the ecosystem, scientific study through experimental management and the development of a program for carrying out restoration. It also requires an understanding of the societal framework of values, ethics, and policy that influence the causes of degradation, the feasibility of its prevention, and the implementation of restoration efforts when degradation occurs. The practice of ecological restoration includes wide scope of projects such as erosion control, reforestation, usage of genetically local native species, removal of non-native species and weeds, revegetation of disturbed areas, reintroduction of native species, as well as habitat and range improvement for targeted species.

Ecological restoration as its goal an ecosystem that is resilient and self-sustaining with respect to structure, species composition and function, as well as being integrated into the larger landscape and supporting sustainable livelihoods. Many healthy ecosystems are the product of human endeavors over very long time periods and therefore restoration commonly requires the participation of the resource dependent communities. In these respect ecological restoration supports the conservation and sustainable development affords worldwide.

There are two major challenges involved when undertaking ecological restoration. One is how to undertake restoration across large areas comprising variety of land uses. The second is how to equitably balance the tradeoffs between improving biodiversity conservation and improvements in human well-being.

There are three alternatives in restoration as follows:

1. Full restoration: Restoration of site to its pre damaged condition.

2. Partial restoration: Restoration of selected ecological attributes of sites.

3 Creation of its alternative ecosystem

## RATIONALE OF RESTORATION

There is consensus in the scientific community that the current environmental degradation and destruction of many of the Earth's biota is considerable and is taking place on a "catastrophically short timescale"(Novacek and Cleland, 2001). Estimate of the current extinction rate is 1000 to 10,000 times more than the normal rate (Wilson, 1988). For many people biological diversity (biodiversity) has an intrinsic value that humans have a responsibility towards other living things, and an obligation to future generations. On a more anthropocentric level, natural ecosystems provide human society with food, fuel and timber. Fundamentally, ecosystem services involve the purification of air and water, detoxification and decomposition of wastes, regulation of climate, regeneration of soil fertility and pollination of crops.

Habitat loss is the leading cause of both species extinctions and ecosystem service decline (Daily *et al.,* 1997). The two ways to reverse this trend of habitat loss are conservation of currently viable habitat and restoration of degraded habitats.

So there is an urgent need for soil reconstruction and restoration of productive and functional soil-plant systems on the abandoned and degraded lands especially mine lands. The recovery of these degraded ecosystems will provide alternative land uses, such as wildlife/amenity parks, grassland/range lands and horticulture plantations. Sustainable land use options and restoration/rehabilitation of these degraded ecosystems will control erosion, halt further degradation and preserve environmental quality.

## APPLICATIONS OF ECOLOGICAL RESTORATION

Applied restoration is a multi-step process, which may include some or all of these stages:

- Assessing the site-a thorough appraisal of the current conditions at the restoration sites is essential for determining what kind of actions will be necessary. In this step, the causes of ecosystem disturbance and methods for stopping or reversing them are identified.
- Formulating project goals-to determine the targets for the restored community, practitioners may visit reference site (similar, nearby environment in natural conditions) and/or consult historical sources that detail the pre disturbance community, goals may also include consideration of what species will be best suited to present future climate conditions.
- Removing sources of disturbance-before restoration can be successful, forces of disturbance may need to be removed. Examples includes cessation of mining or farming or causes of erosion,

restricting live stock from riparian areas, removing toxic material from soil or sediments and eradicating invasive exotic species.

- Restoring processes/disturbance cycles-sometimes restoring important process such as natural flood or fire regimes is enough to restore the ecosystem integrity. In these cases the native plants and animals that have evolved to tolerate or acquire natural disturbance regimes come back on their own without direct action by practitioners.
- Rehabilitating the substrates-this can include any activity aimed at repairing altered soil texture or chemistry, or restoring the hydrological regimes or water quality.
- Restoring vegetation-in many cases restoration activities involve direct revegetation of a site. Usually, native species suited to local environment conditions are chosen for planting. Seeds or cuttings are generally collected from a variety of sources within a local region in order to ensure the genetic diversity. Vegetation can be planted as seeds, or seedlings.
- Monitoring and maintenance- monitoring the restoration site overtime is critical to determining whether the goals are being met, and can inform future management decisions. Observations made at the site may indicate the further action such as periodic weed removal is necessary in ensuring the long term success of the project. Ideally restoration project would eventually achieve the self-sustaining ecosystem without the need for future human intervention.

**REVEGETATION IN MINE SPOILS AND ITS SCOPE**

Ecorestoration have a number of advantages as a post mining land use. First, long-term stabilization of the site is accomplished even though during initial stages some erosion may occur. Second, establishment of desirable tree species capable of maintaining the site will slow or prohibit invasion of less desirable, weedy species. Third, trees will eventually provide economic returns although several decades must generally pass before harvesting. Fourth, tree planting aids in developing wildlife habitat and promotes hydrologic balance in the watershed. Successful initial survival does not always translate into successful long-term site stabilization and development of a forest with commercial value. Re-evaluating tree plantings after many years will aid in prescribing which tree species have long-term survival, show suitable growth and timber production potential, and contribute to the site's overall health in terms of economics, aesthetics, and the environment.

Mine spoils are drastically disturbed and physically, nutritionally and microbiologically impoverished habitats .It needs to be stabilized to prevent erosion and contamination of rivers and

adjoining agricultural lands from harmful leachates. Natural revegetation of mine spoils is a slow process but it can be accelerated by planting suitable tree species. Therefore, evaluation of tree performance is crucial in selection of suitable species for revegetation of mine spoils for their prompt recovery.

**Soil replacement**

Mine reclamation may involve soil amendment, replacement, or creation, particularly for areas that have been strip mined or suffered severe erosion or soil compaction. In some cases, the native soil may be removed prior to construction and replaced with fill for the duration of the work. After construction is completed, the fill is again removed and replaced with the preserved native soil for revegetation.

## GENESIS OF ECOLOGICAL RESTORATION PROJECT IN BCCL

Bharat Coking Coal Limited (BCCL), A Mini Ratna Company (A Subsidiary of Coal India Ltd.), Government of India undertaking, is the major coal mining company and only producer of prime coking coal in India. It operates in Jharia Coal Field (JCF), one of the oldest and important coalfields of India where mining is continuing for more than 125 years. It is located in Dhanbad and Bokaro districts of Jharkhand State. JCF occupies an important place both in India's industrial and energy sectors. Since, the inception of Indian coal mining industry in 1890s, JCF has been an attractive area for mining mainly as it has one of the highest concentrations of thick coal seams in the world and is at relatively short depths.

A long history of more than 125 years of coal mining also includes the history of damage to its land and environment. Prior to nationalization of coal mines, JCF was in the hands of private mine owners until it was nationalised by the Government of India in 1971-73. The mining methods then were, by and large unscientific compared to the present day technology. Mining was carried out with the sole motto of profit making and 'more hole, more coal' without any regard to safety, conservation and environment.

Such type of 'slaughter mining' and un-systematic mining over a long period resulted in change of the original land-use and severe land degradation in the form of quarries, subsidence depressions, coal mine fires, spoil dumps, loss of soil, original topography as well as drainage pattern. Adding to the problem of land degradation, the coalfield is thickly populated with a population density of 2200

heads/sq km which further led to stress on the natural forest and vegetation cover. Besides, air pollution problems due to mining of coal, mine fire, emission of noxious and toxic gases, vehicular emissions, domestic fuel burning and water pollution problems due to mining, urbanization and other industries persist in the coalfield.

**EARLIER RECLAMATION OF DEGRADED LAND: PHYSICAL & BIOLOGICAL**

The total degraded land in the JCF, as estimated by CMPDI in 1986, was 6,294 hectares, details of which are given below.

| S No. | Type of degraded land | Area (ha) |
|---|---|---|
| 1. | Subsided area | 3,497 hectares |
| 2. | Mine fire area | 1,732 hectares |
| 3. | External Spoil Dumps | 641 hectares |
| 4. | Old abandoned pits | 434 hectares |

Biological reclamation of degraded mining land by way of plantation was the first effort of BCCL to tackle land degradation. Large scale afforestation programme was started by BCCL in 1986. Up to 2010-11, BCCL has reclaimed 3676 (3460+79+137) hectares of degraded land through biological reclamation. The land reclaimed is:

| S No. | Type of reclaimed land | Area (ha) |
|---|---|---|
| 1. | Subsided area | 1998 |
| 2. | Mine fire area | 615 |
| 3. | External Spoil Dumps | 556+79+137 |
| 4. | Old abandoned pits | 291 |

Biological reclamation has been carried out mostly by large scale plantation on subsided land, surface areas affected by fires and OB dumps, and so also in colonies and along the coalfield roads. BCCL has planted more than 1.40 crores trees up to 2010-11. The plantation is done departmentally as well as through State Forest Department of Bihar/ Jharkhand, and that of West Bengal.

## METHODOLOGY OF PLANTATION ON BCCL'S AREAS BY DISTRICT FOREST DEPARTMENT

During the first year, the preliminary jobs of survey, demarcation, trenching etc. were done. Subsequently, nursery raising and soil conservation work is done. Further, the plantation work is done in the month of July-August after which weeding and hoeing is done during the 1st year. Constant protection/ guarding were provided by the Forest Department for maintaining these plantation areas. Further weeding and hoeing and protection including replacement of casualties is done during the 2nd and 3rd years.

Most of the trees found on the OB dumps are of exotic origin. Species such as *Acacia auriculiformis, Cassia siamea, Pongamia pinnata, Peltophorum ferrugineum, Leucaena leucocephala, Pithecellobium dulce* along with few native species *Azadirachta indica, Melia azedarach, Dalbergia sissoo* and *Acacia nilotica* are found on the OB dumps. The forest department has done plantation with mono culture single tier species or with only few common species, which are fast growing but not suitable for ecological restoration. These plantation sites do not attract fauna and birds, micro-organisms etc. The ground cover is usually devoid of vegetation and hence got failed to provide nutrient required to improve the structure of rocky land.

Plantation should be done by three-tier method. The lower cover should be herbs and grasses which will provide nutrients to soil and habitat to insects and micro-organisms. The middle tier should be shrubs or small bushes and the upper storey should be big trees. This three tier system will attract fauna, birds and other organisms and will be developed into full fledged forest eco-system, and accordingly the food chain/ food webs shall be established.

Non-mineral bearing area around the OBDs are invaded by some of the top ten worst weeds and these include *Chromalaena* sp., *Parthenium hysterophorus, Hyptis suaveolens,* besides *Lantana camara, Croton bonplandianum* and other noxious weeds such as *Xanthium strumarium.* There is no grass over or native trees on the OBDs. Some patches of *Dalbergia sissoo, Azadirachta indica,* and *Ficus* species have also been observed on the OBDs. In other words even exotic trees failed to establish on upper slopes and tops of 30 to 40 m OBDs and massive slips (landslides) are observed and have been invaded by invasive species.

**Single tier monoculture plantation adopted by District Forest Department**

**Monoculture plantations versus ecological restoration in mined areas**

The monoculture tree plantations do not in any way lead to development of a forest. A tree plantation is not a forest. A forest is complex, biodiversity-rich, self-regenerating system, consisting of soil, water, a microclimate, and a wide variety of plants and animals in mutual coexistence. Forests host more than 70% of terrestrial biodiversity. The simple monoculture plantations neither lead to biodiversity creation nor carbon sequestration as compared to the process used in ecological restoration. The reality is that monoculture plantations have a negative impact on communities, local economies and biodiversity. These plantations are not a solution to climate change or to biodiversity loss. Monoculture plantations have no biodiversity and require ongoing human intervention - including fertilization - as "weeds" must be removed using herbicides and pesticides. In the pretext of developing a self sustained ecosystem in mining areas of Dhanbad with the dual purpose of enriching biodiversity and benefiting the local inhabitants, management of the degraded lands by way of ecological restoration offers the ultimate solution today. Ecological restoration serves several important purposes in the coalfield management scenario. It enhances the biodiversity of the area and develops a self sustaining system which can generate innumerable ecological functions in due course of time. The plantation mainly monoculture plantation can serve for temporary replenishing the lost green cover of the area but it can hardly be of greater use at the end.

**Native species versus exotic species**

Ecological restoration also encompasses the use of native species in the biological approach of land rehabilitation and restoration. There are many advantages in using native species as the native vegetation evolves gradually to live with the local climate, soil types, and animals. This long process brings us several advantages such as:

1. Saves water: Once established, many native plants need minimal irrigation beyond normal rainfall.
2. Low maintenance: Revegetation degraded mined land with native species is a natural fit with native plants that are already adapted to the local environment and thus, there is minimal to no requirement of water, fertilizer, pesticides and pruning.
3. Pesticide freedom: Native plants have developed their own defenses against many pests and diseases. Since most pesticides kill indiscriminately, beneficial insects become secondary targets in the fight against pests. Reducing or eliminating pesticide use lets natural pest control take over and keeps garden toxins out of our creeks and watersheds
4. Wildlife Viewing: Native plants, birds, butterflies, beneficial insects, and interesting critters are "made for each other." Research shows that native wildlife prefers native plants.

## INCEPTION OF ECOLOGICAL RESTORATION IN BCCL

In the year 2011, the Hon'ble High Court of Jharkhand at Ranchi under a Public Interest Litigation Case W.P. (PIL) no. 3633/ 2008 Gramin Ekta Manch versus The State of Jharkhand and Others in different hearings in Dec., 2010 and January 2011 has directed BCCL that they would ensure that the plantation they were making through the agency of the government (ie. through Divisional Forest Office, Dhanbad) should be discontinued as the Government has its own scheme of planting trees, and that BCCL should devise its own mechanism for plantation work and also ensure that plantation work has a higher survival rate. The Court directed BCCL to prepare a Road Map for plantation in mining areas of BCCL.

As, preparation of Road map for plantation work in mined out areas which are significantly degraded, is a highly technical job and BCCL does not have such expertise, BCCL approached "Centre of Mining Environment of the Indian School of Mines, Dhanbad" to carry out scientific study for

preparation of Road map for plantation work. The Indian School of Mines agreed to develop a Road map for plantation for BCCL. But in the subsequent hearing, the Hon'ble Court has directed BCCL to consult and appoint the "Indian Council of Forestry Research and Education (ICFRE), Dehradun" who is expert in the subject for developing the said Road map (Hon'ble Court directives are annexed as Annexure-1)

## MoU for preparing Road map for ecological restoration of BCCL mine areas

BCCL approached "Forest Research Institute (FRI), Dehradun" for preparing road map for ecological restoration of BCCL mine areas and a MoU was signed between FRI and BCCL on 22nd Feb., 2011. FRI, Dehradun agreed to develop a road map/ action plan for ecological restoration of BCCL mine areas. The job had been done by "Ecology and Environment Division" of Forest Research Institute Dehradun.

As per the MoU, the Road map shall include soil working methods, soil and moisture conservation measures, choice of ecologically and socioeconomically viable plant species, methods of preparation of seed mix, methods of seeding and planting for ecological restoration of degraded mine areas. NGO's / agencies who can successfully implement the Road map for ecological restoration /plantation work would also be suggested in the Road map by FRI, Dehradun (copy of MoU is annexed as Annexure-2).

**Rapid Survey of JCF**

An expert team of scientists from FRI, Dehradun visited Dhanbad from 05th March 2011 to 07th March 2011 for conducting a Rapid Ecological Appraisal of the mine sites of Bharat Coking Coal Limited, for the purpose of developing the Road Map/ Action plan for plantation work. The expert team consisted of the following scientists:

| | |
|---|---|
| Dr.(Mrs) Prafulla Soni | Head and Scientist F and a specialist in Forest Ecology, Restoration Ecology and Biodiversity Conversation |
| Dr. H.B.Vasistha | Scientist D and a specialist in Restoration Ecology and Biodiversity Conversation. |
| Dr.(Mrs) Mridula Negi | Scientist B and a specialist in Biomass and Nutrient Cycling. |
| Dr. Lal Singh | R.A.I and specialist in Plant taxonomy. |

During their field visit for rapid assessment of the bio-environmental situation of JCF, the expert team visited mined out and degraded areas in Lodna, Ghanoodih, Bera, Chandmari, Kujama plantation sites, Shatabdi Fire Project, Muraidih OCP, Damoda Fly Ash dumping site, Keshalpur OCP, West Mudidih OCP, Jhunkundar reclaimed area etc. during their stay at Dhanbad from 05th March 2011 to 07th March 2011. The team also collected soil samples from all these sites, located these sites through Global Positioning System (GPS), and inventoried existing plant species. They have also interacted with local people at Naya Dhowra, Bhulanbararee village, Modivita village, Ghanoodih village and Muraidih for assessing needs of the people and their acceptability for forestry etc. The attitude of the local communities was positive during interaction.

**Team of scientists from FRI, Dehradun**

**During the deliberations with the FRI team at Dhanbad, the following facts came into light:**

- As per the FRI experts, the existing practice of plantation being done is not ecologically appropriate. The forest department has done plantation with mono culture single tier species or with 3-4 species, which are fast growing but not suitable for ecological restoration. These plantation sites do not attract fauna and birds, micro-organisms etc. The ground cover is usually devoid of vegetation and does not protect the soil cover and soil improvement does not occur.
- As per the FRI team, the existing plantation done by Forest department is of single tier plantation. As per FRI's opinion, plantation should be a 3-tier method. The lower cover should be small bushes and grasses which will provide bio-mass to soil and home to insects and micro-organisms. The middle tier should be shrubs and the 3rd tier should be big trees. This three tier system will attract

fauna, birds and other organisms and will be developed into full fledged forest eco-system. The food chain/ food webs will be established.

- A separate nursery needs not to be established for planting trees. Seed collection of native and local species from the field has to be done. The plantation inaccessible mined out areas and OB dumps can be done by "hydro-seeding" method. Local species seeds mixed with cow dung, soil, and bio fertilizers have to be spread over the area before the onset of monsoon. The seeds will automatic germinate in a natural way.
- It is required to make an inventory of the local and native plant species and specially colonizers like 'Shisham'. This activity shall be done by FRI in their report. During their field visit, the FRI experts have observed that Shisham is a very good and fast colonizer species on OB dumps. Similarly other colonizing species have to be identified. What is required is human intervention for promoting the natural colonization of these species.
- There are also quite a good number of medicinal plants available in the coalfield, which can be developed with human intervention into medicinal eco-park.
- Rain water harvesting and soil conservation practices have to be integrated with plantation work. The total method will be proposed by FRI in their report.

The FRI team has expressed that though eco-restoration and plantation work in such a highly degraded area like Jharia coalfield is a challenging task but with proper scientific approach and help of the local administration and local people positive results can be achieved. Most of the degraded land in the coalfield can be restored.

## Preparation of Road Map

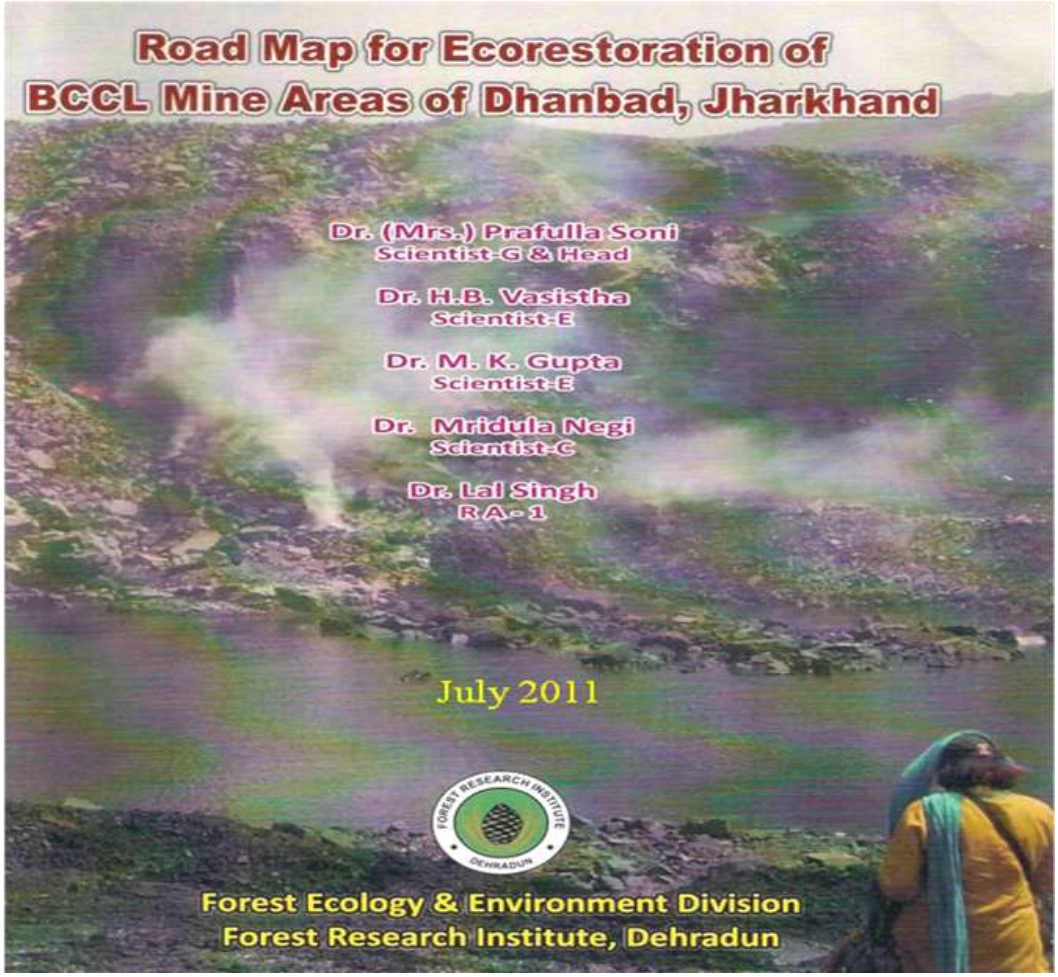
In July, 2011 Road Map for Ecorestoration of BCCL Mine Area of Dhanbad, Jharkhand was prepared by the FRI, Dehradun after a rapid appraisal of the extent of disturbance to biotic and abiotic components of the ecosystem. The major objectives of this road map were to improve productive capability of degraded lands and enhancing the conservation values of landscape. The comprehensive report contained detailed information on the restoration of derelict mine spoils, developing a nursery for medicinal plants, soil and moisture conservation practices and development of an eco park. The report also outlaid the implementation of the project in two phases over a period of ten years. In the first Phase (2011-2016) a field model will be developed by the scientists of FRI, Dehradun which may be replicated

in other areas. During Phase II (2016-2021) replication/ expansion of the proposed restoration models in the 226 hectares area spread over in 13 mines of BCCL would be done.

## SUBMISSION AND SUMMARY OF THE ROADMAP

The road map was submitted in the month of April 2011. The summary of road map is as follows:

- Landscape of Jharkhand is fragmented because of the large tracts of mined lands. This has resulted in ecological imbalance due to disturbance in air, water, loss of topsoil as well as flora and fauna. Mining of minerals, roads and rails construction, dams and irrigation schemes, construction of mineral based factories and industries, stone quarrying and unrestricted grazing by free range cattle etc. have exerted pressures on the bio-diversity of the state.
- Restoration of these derelict landscapes based on ecological principles is the only answer for the speedy recovery of not only ecological systems but also for improve the socio-economic potential of these areas. Besides carbon footprint of mining and other related activities will be reduced effectively within a short span of time.
- Keeping these facts in view the road map for ecological restoration of mines of Bharat Coking Coal Limited in Dhanbad district has been prepared after a rapid appraisal of the extent of disturbance to biotic and abiotic components of the ecosystem. The major objectives for preparation of this road map are to improve productive capability of degraded lands and enhancing the conservation values of landscapes through:
    1. Development and conservation of soil and *in-situ* moisture conservation through ecological restoration interventions;
    2. Restoration / regeneration of degraded lands including forests and adjoining areas on an ecological basis;
    3. Intensification of the availability of fuel wood, fodder, grasses and other forest usufructs from the restored areas;
    4. Securing people's participation in planning and restoration efforts in the surrounding villages to ensure sustainability.




**Cover page of the Road Map**

Besides, restoration of derelict mine spoils, developing a nursery for medicinal plants, soil and moisture conservation practices, development of an eco-park in the already quarried area and awareness and capacity building initiatives have also been considered.

- The total project has to be implemented in two phases over a period of ten years. In the first phase (2011-16) a field model will be developed by scientists of FRI, Dehradun which may be replicated in other areas. During phase-II, 2016-2021 Replication / expansion of proposed restoration models in the 226 hectares area spread over in 13 mines of BCCL. The critical role played by the various institutions in the context of execution of plan is well recognized. The various major stakeholders in the BCCL area have to jointly chalk out a strategic execution plan. The major stakeholders in the region are BCCL and local communities.

- It is expected that execution of the ecological restoration will in the long term contribute to mitigation of adverse impacts on the microclimate in the district as well as state and country at large.


**Mined out degraded land to be used for eco-restoration over the years**

**Trainings imparted to the BCCL officials at Dehradun**

With a view to develop a forestry team dedicated to ecological restoration in all the 12 operational areas or collieries of BCCL more than 30 persons have been trained at FRI, Dehradun in various aspects of ecological restoration of mined lands. The trainings were conducted in two batches; the first batch underwent training from 27th June, 2011 to 1st July, 2011, while the second batch had their training from 25th July, 2011 to 29th July, 2011. The main objective of the training programme was to abreast the participants about the measures taken in restoration of coal mines particularly in the Jharia coal mine areas, Jharkhand.

**BCCL's officials during training at FRI, Dehradun in 2011**

**Training arranged by BCCL for local villagers through FRI**

BCCL had also trained more than 130 local villagers and unemployed youths in the methods of ecological restoration through FRI scientists in January, 2012. This was done with the objective for creating livelihood opportunities to the unemployed youths of Dhanbad district as well as upgrading the surrounding environment through ecological restoration.


**FRI's officials while interacting with local villagers of Dhanbad**

## Developing Ecological Restoration Model in the Mine Spoils at Tetulmari under Sijua Area (About 8-10 ha) of BCCL Mine

Bharat Coking Coal Limited, Dhanbad (BCCL) signed a MoU in July 2011 for availing technical expertise and capabilities of FRI by way of:

1. Procuring technical consultancy from FRI to Bharat Coking Coal Limited for developing ecological restoration model in mine spoils at Tetulmari, Sijua area (about 8-10 ha) of BCCL mines.
2. Seeking assistance of FRI scientists for execution in soil working, soil and moisture conservation measures, selection of plant species, preparation of seed mix, seeding and planting in mined out area.
3. Conducting periodic ecological monitoring of treated mined area by FRI.
4. Documenting and producing annual ecological monitoring report by FRI and submission thereof to Bharat Coking Coal Limited, Dhanbad.

FRI was responsible for providing all necessary technical support to BCCL Dhanbad as and when requested by deputing their Scientists, Junior Research Scholar and other staffs to achieve the success of development of model ecological restoration in mined out areas at Tetulmari, Sijua in about 8-10 ha area for the period of three years. The work included, site preparation, soil working, soil and moisture conservation measures, selection of ecological and socio economic viable species, preparation of seed mix, seeding and planting in mined out areas. Accordingly, the work has been started from July, 2011 in about 8-10 ha coal mined over burden dumps.

The project started with following objectives:-

1. To stabilize overburden dumps to control erosion
2. To conserve and enhance the biodiversity of mined out areas
3. To generate natural resources to cater the needs of local people
4. To develop aesthetic view of mined out area.

### STUDY AREA

Dhanbad district, in the state of Jharkhand, also known as the 'Coal Capital of India', is one of the most industrialized districts of the state. It is situated between $23^0$37’3’’ N to $24^0$4’N latitude and $86^0$50’E longitude. Giridih bound it in the north, Bokaro in the west, Purulia district in the south and Jamtara district in the east (Fig. 1). It is connected through NH-2 and NH-32 from state capital and

different district headquarters of the state. The district has total area of 2089 sq. km. The Dhanbad district consist of 8 blocks namely Baghmara, Baliapur, Dhanbad, Govindpur, Jharia, Nirsa, Topchanchi and Tundi. The district comprises of 157 numbers of panchayats and 1052 no. of villages. The total population of the Dhanbad district as per the 2011 census is 23, 97,102 in which rural population is 11, 41,744 and urban population is 12, 55,358. The density of population is 1167 person per sq. Km.

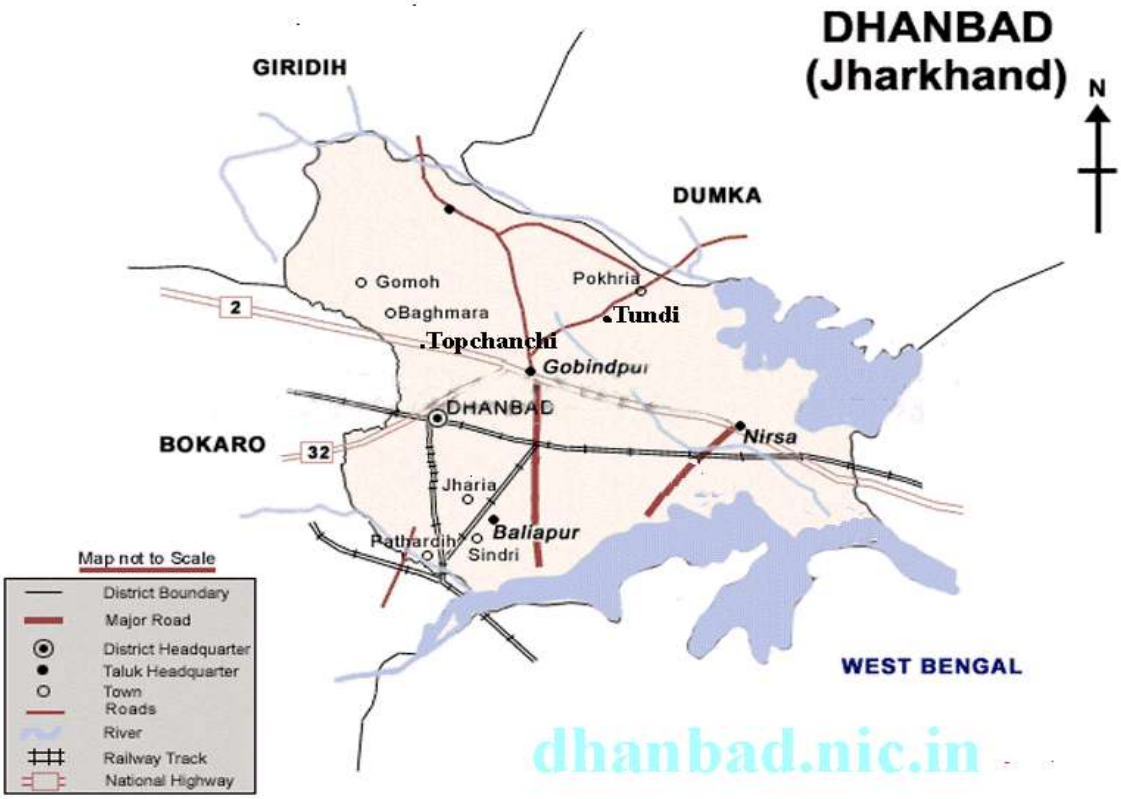



**Fig. 1: Map of Dhanbad district**

## Climate

Dhanbad district experiences sub-tropical climate, which is characterized by hot summer from March to May and well distributed rainfall during southwest monsoon from June to September. Winter season in the area is marked by dry and cold weather with intermittent showers during the month of December to February. Dhanbad area is climatically different from neighboring regions. The important climatic elements such as temperature, precipitation, pressure, and wind velocity show great variation.

Three broad climatic seasons are found - (1) **the winter season** lasting from November to February. The months of December and January are the coldest. (2) **The summer season** begins from March and lasts till May. During April the wind blows from the west. It remains relatively hot and temperature rises around $40^0$ C. (3) **The Rainy season**-This season normally begins from the middle of June, when the monsoon winds bring moisture-laden clouds from the Bay of Bengal.

## Temperature

Long-term data of temperature shows that it decreases progressively after October. The winter season starts from November and last till February. January is the coldest month with the mean daily maximum temperature of $30^0$ C and the mean daily minimum temperature of $14.9^0$ C.

## Rainfall

Dhanbad areas receive more rainfall due to coal dust, which attracts clouds and bring rainfall to the area**.** Rainfall is the principal method of groundwater recharge to ground water. Southwest monsoon brings rainfall to this area during the months of June to October mainly. Normal data of the Dhanbad I.M.D. observatory indicates an average of 1310.6 mm of rainfall.

## Physiography

The northern part of Dhanbad is covered with hills and thick forest. In general the altitude varies from 133 m above MSL in Chirkunda to 745m above MSL in Parasnath hills. Dhanbad district can be divided into two parts.

1) Northwestern hill ranges of Parasnath having parts of Topchanchi, Tundiblocks. These regions have general slope towards south.

2) Areas covered by Damodar and its tributaries like Barakar. The area comprises of coalfield areas and alluvial tracts.

## Soils

The soils of the district are mostly of the residual type. High temperature and high rainfall have led to the formation of lateritic type of soils from rocks of Archean metamorphic complex exposed in the greater part of the district and also from the lower Gondwana rocks in the west-central and east central parts. Texturally the soils of the district have been classified into four classes-

**a. Stony and gravelly soils--** These are low-grade soils having a large admixture of cobbles, pebbles and gravels generally found at the base of the hills.

**b. Sandy soils-** These types of soils are generally found near the river and streambeds. They contain more than 60 percent sand and poor in plant nutrients. They are also called hungry soils because of heavy manuring required.

**c. Loamy soils--** They consist mostly detritus of decomposed rocks and vegetable matter and contain between 30 to 60 percent sand.

**d. Clayey soils-** These soils are sticky when wet and very hard and difficult to break when dry. They are very fertile but yield in such soils improve with addition of sand, lime, coarse bulky manures etc.

## Forest resources and covers in Dhanbad

Jharkhand, one of the most important mineral producing states, came into existence on November 15, 2000 by carving out from the erstwhile State of Bihar. It has a geographical area of 7.97 million ha. which is 2.42% of the land area of India. It has between latitude $22^0$ 0' and $24^0$37'N and longitude $83^o$15' and $87^o$01'E . Geography of the state is marked by the plateau of Chotanagpur, four major rivers are - the Son, the Koel, the Damodar and the Swarnrekha.

The total population of the state is 26.01 millions (Census 2011) of 77.8% are rural and rest are urban population; density of the state is 338 persons per $km^2$.

## Forest Resources

The recorded forest area is 23,605 $km^2$ which is 29.611% of the geographical area of the state. By a legal status, reserved forest constitutes 18.83%, protected forests 81.14%, and unclassed forests 0.03%. The Chhotanagpur plateau is rich in forest. There are three major types of forest, tropical moist deciduous, tropical dry deciduous and subtropical deciduous forest.

## Forest cover in Dhanbad

Dhanbad has very less forest covered compare to other districts of Jharkhand (Fig. 2). It comes second among least covered districts in Jharkhand after Deoghar. Dhanbad has 296 $km^2$, in which 45 $km^2$ has dense forest and 163 $km^2$ open forest. Overall it has total forest area is 22149.50 hectare.

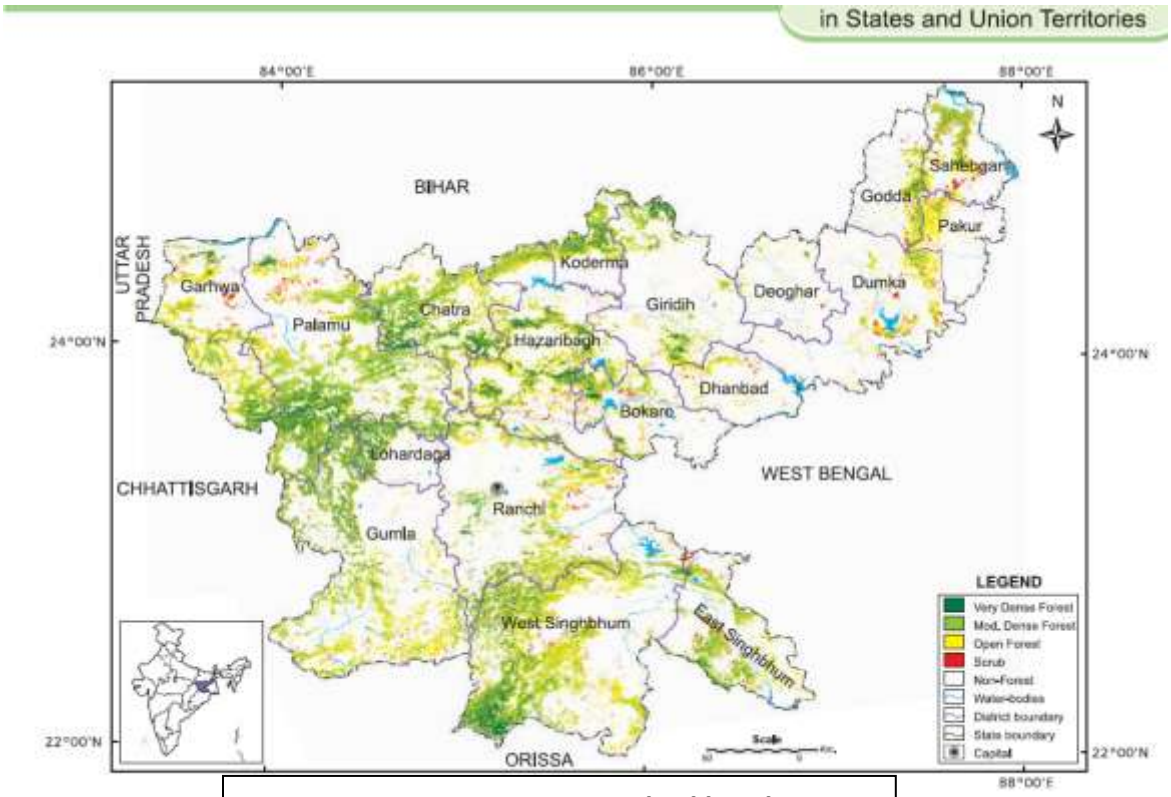



**Fig. 2: Forest cover in Jharkhand**

## Forest types of Dhanbad

The forests of the Dhanbad Forest Division confirm broadly of Champion and Seth's (1968) sub group 5-B, namely northern tropical dry deciduous forests. According to the same classification, they fall in the following sub-types:-

**Sub-types**

**1. Dry Peninsular sal forests.... 5/BC**

**2. Northern dry mixed deciduous forest..... 5B/C2**

**3. Dry deciduous scrub ..... 5B/DS1**

**4. Dry bamboo brakes ..... 5B/E9.**

**Dry Peninsular forests:** This type of forest is found on the northern aspects and in valley of Topchanchi and from plain to undulating land lying on the north and north eastern slopes of Tundi. Patches of pure Sal (*Shorea robusta)* crop in saplings to young pole stage are found in Chas and Chandankiari areas also. The forests as a whole are very poor in timber content. Sal trees above pole stage are few and far in between. Large size trees in the remote hills belong only to the inferior

miscellaneous species like lac hosts, Kusum (*Schleichera oleosa*) and Mahua (*Madhuca longifolia*). The plain forests on the north east and east of Tundi pahar and in Chas and Chandankiari contain almost pure crop of sal sapling and poles. The forests are moderately stocked and are interspersed with open patches where soil erosion is common.

The main associates of Sal (*Shorea robusta*) are Kendu (*Diospyros melanoxylon*), Asan (*Terminalia tomentosa*), Mahua (*Maduca indica*), Dhaura (*Anogeissus latifolia*), Pair (*Buchnania lanzan*) Sidha (*Lagerstromia parviflora*), Bahera (*Terminalia belerica*), Karam (*Adina cordifolia*), Bagal (*Cochlospermum religiosum*), etc. Palas (*Butea monosperma*) and Khair (*Acacia catechu*) are associated on heavy soils and eroded sites respectively. But Khair does not occur in large number any where in the division. Bamboo is found on the hills thinly distributed and its incidence is inversely proportional to that of Sal. The undergrowth consists mainly of Dubkhoraiya (*Holarrhena antidysentrica*) and Kando (*Carissa opaca*). The ground is generally bare. Climbers occur in moist valley bottom or in sheltered valleys. The commonest climbers are *Bauhinia vahlii, Combretum decandrum, Millettia auriculata* and *Spatholobus roxburghii*. The density of the crop is 0.6 and below. Natural regeneration of Sal is almost absent, coppice regeneration is satisfactory but is not allowed to grow unless rigid protection against grazing and illicit cutting is provided.

**Northern dry mixed deciduous forest:** The drier aspects of Topchanchi and Tundi hills and other scattered hills in the division do not carry Sal but contain mixed species. This type also occurs on the shallow soils and degraded sites on the plains. The main species occurring are Dhaura (*Anogeissus latifolia*), Asan (*Terminalia tomentosa*) Kendu (*Dispyros melanoxylon*), Pair ( *Buchnania lanzan*), Sidha (*Lagerstromia parviflora*), *Lannea coromandelica,* Kala ( *Bridelia retusa*). Piasal (*Pterocarpus marsupium*), Gamhar (*Gmelina arborea*), Siris (*Albizia odoratissima*), Galgal (*Cochlospermum religiosum*), Bahera (*Terminalia belerica*), Parasi (*Cleistanthus collinus*), Bel (*Aegle marmelos*), Palas (*Butea monosperma*), etc. Semal (*Bombax malabaricum*), Khair (*Acacia catechu*), Mahua (*Madhuca indica*) are found scattered in the forests. Salai (*Boswellia serrata*) one of the common species in dry mixed deciduous forests in other parts of Jharkhand is almost absent here except a few poor specimens in Tundi Pahar. The miscellaneous forests in the catchment area of the Rajdaha reservoir (Jharia Water Board) which are being preserved for causing the life and function of the reservoir are of good quality in density and growth. Elsewhere forests are thin and poor in quality. Good quality bamboo forests are found mixed with the miscellaneous forests. The undergrowth consists of *Holorrhena antidysenterica*,

Ber (*Zizyphus mauratiana*), Kanoda (*Carissa opaca*), Harsingar (*Nyctanthes arbortristis*), etc. *Lantana camara* is spreading fast in much area and has occupied the lower hill slopes. The crop in this type is generally open, the average density is 0.2 to 0.4, average diameter is 10-15 cm, and average height is 6 to 8 meters. The ground remains bare for most of the year. Natural regeneration is absent. Coppice regeneration is not allowed to grow due to heavy incidence of grazing and fire, except in remote areas.

**Dry deciduous scrub:-** In mining areas near habitation and in easily accessible forests where unsystematic exploitation and unrestricted hacking have been practiced for year, the forests have been degrade to scrub growth. Extremely xerophytic condition has set in and species like Lantana sp, Ber, Bantulshi (*Hyptis suaveolens*) and *Combretum* have occupied the ground. This type of forest is found on the foot of Tundi and Topchanchi hills.

Extensive good bamboo clumps are located in Raja- banspahar, Gansi sikander, Daludih. Here the bamboo grows to 8-10 cm dia. and about 15 -18 meters in height. Bamboo is also found scattered on steep rocky slopes and in dry places in rest of the division but these do not form regular brakes. Bamboo has also been raised artificially in different plantation areas of the division, for example in Brindaban, Burhinor plantation, where good quality bamboo has been raised.

**Blanks:** Blanks both large and small are fairly common and are widely scattered both in hills and plains. Some of the blanks are totally bare while some have dense cover of *Ocimum gratissimum* and *Lantana sp*. Bushy growth of species like *Diospyros melanoxylon* and *Butea monosperma* with scattered trees of Mahua (*Madhuca indica*) and Semal (*Bombax ceiba*) may occasionally be met with. Human interference has played an extremely influential part in the determination of the composition of forests. It is single factor which has considerably affected the existing vegetation of this division for the last so many decades. It is undoubtedly reasonable that climatic topographic and edaphic condition also played their parts, but their roles were subordinated to biotic factors. Greater part of these forests belonged to private owners. These were mercilessly exploited and mismanaged by them due to lack of technical knowledge. In addition to the private owner there was unrestricted exploitation by local people and unrestricted grazing by cattle. Combined effect of these resulted in continuous maltreatment and over-exploitation of the crop for a long period resulting in consequent deterioration. The vegetation in most part of the division has degraded to high pollarded stumps of Tundi and Chas range. The socio-economic condition is such that a large section of local population depend almost entirely on forest produce for their livelihood. This is partly met with by committing theft within the forest areas. Due to

factors stated above, there is gradual reduction in the quality and density of forests property. The quality and composition of the crop varies considerably due to variations of soil and maltreatments. In Topchanchi and Tundi zone which from the compact blocks of forests high stumps pollard shoots and few inferior species were noticed which indicate maltreatment of the vegetation by local people. In Chas area, natural vegetation has been practically ousted. Only few patches continue to survive on much reduce size and shape. Here species like Lantana (*Lantana camara*), Dudhkoriya (*Holarrhena antidysentrica*), Harsingar (*Nyctanthes arbortristis*), Ber (*Zizyphus mauratiana*), etc., are frequent growing to the dry condition created by maltreatment. Palas *(Butea monosperma*) may also be seen in patches.

## Tetulmari colliery of Sijua Area

The study area is Tetulmari Collieries which comes under Sijua Area of Bharat Coking Coal Limited. The area Tetulmari is located at 23°48'210" N and 86°20'527" E and at an elevation of 704.9 m above mean sea level. It is 38 km north- east ward to main town. Tetulmari is well connected by road and railway from main town Dhanbad.

**Topography** – The area has an undulating topography. The maximum and minimum elevation from the mean sea level is 210 m and 170 m respectively. The general slope of the area is towards south i.e. towards Damodar river. The topography of the river has been disturbed due to open cast mining.

**Drainag**e – The drainage of the area is mainly controlled by Jarian nala flowing from north to south to mid Katri nala. Jarian nala has two main tributaries; one is Nagri jore nala which flows form the central part and Ekra jore nala flows along northern boundary of the area. Both the nalas flow from north to south to meet Jarian nala in the south of the area, which ultimately meets Katri nala. Finally Katri nala joins the Damodar river which is the master drainage of the area. The area is located in the Jarian nala Watershed and this Watershed falls within northern part of Damodar basin, which comes under Lower Ganga basin (Source: CGWB, Watershed Atlas map of India).

**Geology of the area** – The area is located in Jharia Coalfield. The Jharia Coalfield represents the middle-east part of coal basin in the Damodar Valley Basin Belt. It is roughly sickle shaped on plan and covers and areas of 450 sq.km.

**Climate** – The area belongs to sub humid tropical climate region. The maximum temperature during summer shoots upto 45$^{o}$ C and during winter, the temperature falls between to 10$^{o}$ C to 5$^{o}$ C. The maximum rainfall occurs during June and September.

**Natural vegetation in the area** – Characteristic forest types of the area, distributed along the topographic is mainly tropical moist deciduous forest and tropical dry deciduous forest. Distribution of forest is fragmented and restricted to the patches between west and west to southwest portion of the area. Within the forest there are large patches of open scrubs with rural settlements. At several places the forest boundary is fragmented due to road.

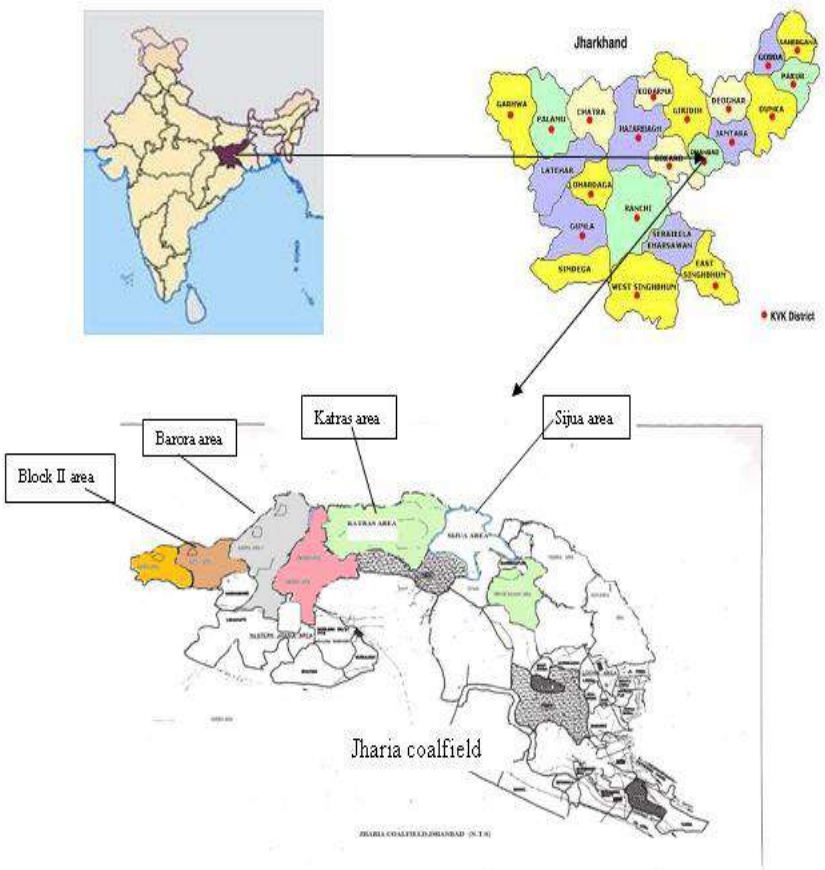



**Fig. 3: Location of study area**

**WORK DONE DURING PROJECT PERIOD ( 2011-2014)**

The mined out area including OB dumps which was taken for development of model restoration was about 14 years old, and was fully invaded by the exotic weeds particularly by *Lantana camara, Eupatorium odoratum, Heptis suaveolens.* As no interventions were made earlier in these OB dumps, the removal or eradication of weeds particularly *Lantana camara* from the site was much needed prior to start of restoration activities to achieve the objectives of the restoration programme. Therefore, the restoration programme in Tetulmari area started with the following action plan:

- Eradication of weeds
- Soil moisture conservation
- Selection of species
- Earth work
- Selection of suitable method of propagation/multiplication of selected species for planting
- Monitoring of survival rate, growth of planted species and change in soil physical and chemical properties

## Eradication of weeds

Three common weeds namely *Lantana camara, Eupatorium odortatum and Heptis suaveolens* were fully invaded on 14 years old OB dump. Before starting restoration activities these weeds were removed in phase wise manner. BCCL personnel who obtained training in FRI on Restoration of mined lands helped in uprooting of weeds in addition to the engagement of labours. Parts of uprooted weed material were also used as mulching on exposed OB dump areas.

The weeds like *Lantana camara, Eupatorium adoratum and Heptis suaveolens* had again infested the entire project area. Weeds have been a major problem in the project site. The reoccurrence of weeds have direct impacts on the other plants by direct competition for sunlight, nutrients, and water and/or by allelopathy. So in the second year, again efforts were made to eradicate the weeds to allow the space for already planted species as well as for new propagation of planting material. The eradication of the weeds from the site has been done manually i.e. uprooting on regular basis throughout the year.

**Project area covered with *Lantana camara* before implementation of project**

**Removal of *Lantana camara* from the project site**

## Soil moisture conservation by means of mulching

To conserve the soil moisture in a place, the weeds removed from the mined out area along with the grass collected from other areas have been spread over the OB dump as a mulch material. In due course of time besides conserving the substratum moisture these mulch materials will also add nutrients to the exposed OB dump through the process of decomposition.

Moisture is the major component of the soil in relation to plant growth. If the moisture content of a soil is optimum, plants can readily absorb soil water. Not all the water, held in soil, is available to plants. Much of water remains in the soil as a thin film. Soil water dissolves salts and makes up the soil solution, which is important as medium for supply of nutrients to growing plants. The soils hold water (moisture) due to their colloidal properties and aggregation qualities. The water is held on the surface of the colloids and other particles and in the pores. The forces responsible for retention of water in the soil after drainage are due to surface tension and surface attraction and are called surface moisture tension. The loose and sandy texture of coal OB dumps does not retain water for longer times and the rainwater percolates laterally and flow as runoff without making it available to the growing plants. So to slow down the process of runoff of the rain water and retain moisture, mulching is done.

Mulching enriches and protects soil. It provides a better environment for the growth of plants. Mulching conserves moisture and reduces the need of frequent watering. Organic mulches also improve the condition of the soil as these mulches decompose slowly and add organic to the soil which makes the soil porous. It enhances root growth, increases the infiltration of water, and also improves the water-holding capacity of the soil. Organic matter is also a source of plant nutrients and provides an ideal environment for earthworms and other beneficial soil organisms. On the project area conservation of moisture was a priority as the climate was very hot and dry. The mulch used was obtained mainly from the weeds which were uprooted from the site as well as grass from office compounds. These mulch materials were used after drying first in the site than spread over the requisite area. The mulching was particularly done on the slopes so that enough moisture could be conserved for planting in the next planting season.

**Mulching on the exposed OB dumps**

**Planting after adopting soil moisture conservation measures**

## Selection of Species

Based on existing climatic conditions, substratum quality and considering socio-economic aspect, a number of plant species has been identified and used in the restoration process.

## Earth work

At a number of places on the site, which were suitable for direct seedling planting, pits of 2'x2'x2' size were dug out. Approximately 11,000 pits were dug out all over the area. These pits were again filled by the same dug out material after planting of seedlings. However, top soil brought from nearby mining area and cow dung manure has also been used for better result.

**Pit digging on OB dumps**

**Filling of pits with the soil and manure (3:1)**

## Selection of suitable methods of planting

Depending upon seed source, seed size and regeneration capacity of the species, the selective plant species were propagated by adopting following methods:

**1. Direct seed sowing**

The species whose seeds were bigger in size and have ability to regenerate on exposed barren areas were propagated through direct seed broadcasting. Seeds of about twelve tree species and six shrub/ bushy species have been broadcasted over the area (Table 1).

**Table 1. Seed mix for OB dumps**

| Sl. No. | List of Species | Local Name | Family | Uses |
|---|---|---|---|---|
| 1. | *Acacia nilotica* | Kikar/Babool | Mimosaceae | Fodder, medicinal |
| 2. | *Aegle marmelos* | Bale patthar | Rutaceae | Fruit edible, medicinal |
| 3. | *Albizia lebbeck* | Kala sirus | Mimosaceae | Timber, medicinal |
| 4. | *Albizia procera* | Sirus | Mimosaceae | Timber, Medicinal |
| 5. | *Bauhinia purpurea* | Kachnar | Caesalpiniaceae | Fodder, Medicinal |
| 6. | *Bombax ceiba* | Semal | Bombacaceae | Fruit edible, Cotton, Medicinal |
| 7. | *Cassia fistula* | Amaltash/Songash | Caesalpiniaceae | Ornamental, Medicinal |
| 8. | *Dalbergia sissoo* | Shisham | Fabaceae | Timber, Soil Fertility |
| 9. | *Melia azaderach* | Bakain | Meliaceae | Timber, Fodder |
| 10. | *Moringa oleifera* | Sahjana | Moringaceae | Flower edible, Fodder |
| 11. | *Pithecelobium dulce* | Jungle jalebi | Mimosaceae | Soil fertility |
| 12. | *Pongamia pinnata* | Karanj | Fabaceae | Soil fertility, Seed oil |
| 13. | *Crotalaria juncea* | Sanai | Fabaceae | Soil fertility |
| 14 | *Dodonaea viscosa* | Jungli mehandi | Sapindaceae | Soil binder |
| 15. | *Indigofera trita* | Neel | Fabaceae | Fertility |
| 16. | *Mimosa pudica* | Lajvanti | Mimosaceae | Medicinal |
| 17. | *Mucuna pruriens* | Kaunch | Fabaceae | Medicinal |
| 18. | *Withania somnifera* | Ashawa ghandha | Solanaceae | Medicinal |

**Seed broadcasting on OB dump**

## 2. Seed mixed soil ball

The species whose seeds were very small in size and difficult to regenerate by direct seed broadcast, their seeds were first mixed in soil with water and prepared soil balls. These seed mixed soil balls were then spread over the area. About five grasses including Bamboo and two herbaceous plant species were propagated by using this practice.

**Mixing of seeds in soil**

**Preparation of seed mixed soil balls**

**Table 2. Seed mixed soil balls**

| S.No. | List of Species | Local Name | Family | Uses |
|---|---|---|---|---|
| 1. | *Bamboosa bambos* | Bans | Poaceae | Soil binder, Making household goods |
| 2. | *Cenchrus ciliaris* | Sui grass | Poaceae | Soil binder |
| 3. | *Cenchrus setigerus* | Dhaman grass | Poaceae | Soil binder |
| 4. | *Cynodon dactylon* | Doob grass | Poaceae | Soil binder |
| 5. | *Panicum nitidum* | Gini grass | Poaceae | Soil binder |
| 6. | *Saccharum benghalense* | Kans | Poaceae | Soil binder |
| 7. | *Stylosanthes hamata* | Hamata | Fabaceae | Soil binder, Nutrient enrichment |
| 8. | *Trifolium repens* | Kasni | Fabaceae | Nutrient enrichment |

### 3. Planting of Seedlings

In addition to seed broadcasting either by direct seed sowing or seed mixed soil balls a number of plant species mainly tree species were propagated through seedling planting.

**Planting of seedlings in mined area**

**Table 3. List of species planted on OB dumps**

| Sl. No. | Botanical name | Common name | Family | Uses |
|---|---|---|---|---|
| 1. | *Albizia lebbeck* | Kala siris | Fabaceae | Fodder, medicine , timber |
| 2. | *Albizia procera* | Siris | Mimosidea | Fodder, fuel, fibre,timber |
| 3. | *Artocarpus heterophyllus* | Kathal | Moraceae | Food , medicinal |
| 4. | *Azadirachta indica* | Neem | Meliaceae | Medicinal, Timber |
| 5. | *Bamboosa bambos* | Bans | Poaceae | Timber |
| 6. | *Bombax ceiba* | Semal | Bombacaceae | Medicinal |
| 7. | *Cassia fistula* | Amaltas | Fabaceae | Medicinal |
| 8. | *Dalbergia sissoo* | Shisham | Fabaceae | Timber |
| 9. | *Madhuca indica* | Mahua | Sapotaceae | Medicinal, timber |
| 10. | *Mangifera indica* | Aam | Anacardiaceae | Fruit edible, timber |
| 11. | *Emblica officinalis* | Aonla | Euphorbiaceae | Fruit edible |
| 12. | *Pongamia pinnata* | Karanj | leguminoceae | Fodder, feed |
| 13. | *Psidium guajava* | Amrud | Myrtaceae | Fruit edible, medicinal |
| 14. | *Syzygium cumini* | Jamun | Myrtaceae | Fruit edible, medicinal |
| 15. | *Terminalia arjuna* | Arjun | Combretaceae | Medicinal |
| 16. | *Zizyphus nummularia* | Ber | Rahmnaceae | Fruit edible |

**4. Stem cutting**

Certain plant species like *Vitex negundo* were propagated in the area through stem cuttings. About 1000 stem cuttings were planted particularly along the boundary of the area.

**Stem cuttings of *Vitex negundo***

**Growth and establishment of *Vitex negundo* after 3 years**

**5. Culm/slip**

Grass species like *Arundo donax, Cymbopogon nardus, Saccharum benghalense, Pennisetum purpureum , Panicum maximum* were propagated through culm/slip planting.

**Growth and establishment of *Pennisetum purpureum* on OB dump**

## 6. Bulbils

*Agave sislana* which is used as live fencing also planted through bulbils along the boundary of the area. These bulbils were collected from Dehradun forest areas and transported to the Tetulmari coal mined area. The bulbils planted in the course of three years have shown positive results. They were extensively used for raising biological fences around the project site.

**Planting of bulbils of *Agave sislana***

**Expected result after 5 years**

In this way a total 34 number of plant species including 16 tree species, 7 shrubs, 7 grasses, 3 herbaceous and one Bamboo species were planted by way of various means as discussed above. These species are of multi uses like timber, fodder, medicinal, edible, soil binder, soil enrichment etc.

## Species survival and establishment

Species growth and survival rate were monitored during the course of study. In spite of heavy biotic disturbances particularly due to cattle grazing and movement of local people in the area there was sufficient regeneration of seed broadcasted as well as growth of planted species. Among planted species *Dalbergia sissoo, Azadirachta indica, Emblica ofiicinalis* were recorded to be highly successful species. Similarly among grasses *Cenchrus ciliaris* and *Cenchrus setigerus* were found to be the promising species. In addition to these grasses there are certain grass species like *Pennisetum pedicellatum* has also started invading in the area.

## OTHER SPECIFIC ACTIVITIES CARRIED OUT DURING THE PROJECT PERIOD

### Collection of soil samples and their analysis

Soil samples of overburden materials were collected from two different phases of the project site. The soil samples were carefully collected in polythene bags and their openings were tied with rubber bands. The soil samples so collected were analysed for their physico-chemical characteristics in the soil laboratory of FRI, Dehradun.

**Table 4. Physico- chemical properties of the soil of the project area**

| **Physical properties** | | | | | |
|---|---|---|---|---|---|
| | **Bulk Density ($g/cm^{3)}$** | **Porosity (%)** | **Texture (%)** | | |
| | | | **Sand** | **Silt** | **Clay** |
| Flat areas of the site | 1.21 | 34.8 | 86.35 | 6.0 | 7.64 |
| Slopes of the site | 1.26 | 33.3 | 86.36 | 5.4 | 8.24 |
| **Site average** | **1.24** | **34.05** | **86.36** | **5.7** | **7.94** |

| **Chemical properties** | | | | | |
|---|---|---|---|---|---|
| | **pH** | **Organic carbon (%)** | **Available Nitrogen (kg/ha)** | **Available Phosphorus (kg/ha)** | **Available Potassium (kg/ha)** |
| Flat areas of the site | 7.18 | 0.84 | 264.32 | 0.64 | 2.56 |
| Slopes of the site | 7.10 | 0.99 | 349.44 | 1.12 | 2.64 |
| **Site Average** | **7.14** | **0.92** | **306.88** | **0.88** | **2.6** |

Soil of Tetulmari site was neutral in reaction. Soil organic carbon was slightly moderate with 0.92 %. Soil was well enriched by nitrogen (306.88 kg/ha 0.014%) while exchangeable potassium (2.6 kg/ha or 0.002 %) and available phosphorus (0.88 kg/ha or 0.012 %) were very low. Soil texture indicates the high content of sand with 86.36 % followed by clay, 7.94 % and silt with 5.7

## Assessment of growth performances of some selected plant species

Indigenous species were preferred for ecological restoration of the site because of their ability to colonize hostile environments, enhance soil fertility and meet the livelihood and cultural needs of the local communities. The study during the second and third years includes growth assessment of some species like *Dalbergia sissoo, Albizia procera, Albizia lebbeck, Phyllanthus emblica, Bauhinia purpurea.*

**Table 5: Survival and growth performance of planted species after three years**

| Species<br>A. FORESTRY | Avg. height after 3 years (cm) | Avg. diameter after 3 years (cm) | Survival % After 3 years |
|---|---|---|---|
| *Albizia procera* | 397.6 | 6.24 | **90** |
| *Dalbergia sissoo* | 275.1 | 3.76 | **90** |
| *Bauhinia variegata* | 244.2 | 3.48 | **85** |
| *Albizia lebbeck* | 157.8 | 2.15 | **86** |
| *Pongamia pinnata* | 87.0 | 1.20 | **90** |
| **B. HORTICULTURAL** | | | |
| *Emblica officinalis* | 298.0 | 5.52 | **88** |
| *Mangifera indica* | 151.2 | 3.55 | **60** |
| *Artocarpus heterophyllus* | 127.0 | 2.73 | **55** |
| *Syzygium cumimi* | 122.0 | 2.07 | **90** |
| *Psidium guajava* | 99.3 | 1.16 | **80** |

The data depicted in the Table 6 indicates that *Dalbergia sissoo* and *Pongamia pinnata* have the highest survival percentage with 90 % each while in case of horticultural species the survival of *Syzygium cumini* was 90 % followed by *Emblica officinalis* with 88 % and *Psidium guajava* with 80%. The survival of other forestry species i.e., *Bauhinia variegata, Albizia procera* and *Albizia lebbeck* was more or less similar ranging in between 85% to 87%. In case of horticultural species, *Artocarpus*

*heterophyllus* and *Mangifera indica* have exhibited comparatively low survival percentage i.e., 55 % and 60 % respectively.

## Use of pitcher irrigation technique on the site

An experiment was set in order to determine the comparative growth of the selected species under different conditions of water availability. Some plants were provided with earthern pots with a minute hole at the bottom of the pitcher so as to enable continuous but less supply of water while others were left out to use only the water available through rain. This was similar to drip irrigation, but less expensive to install. The pitchers are the round earthen containers used in rural areas for water storage, ranging from 10 to 20 litres in capacity. It is also very good way of irrigation for saplings and promote deep root growth. Soluble fertilizers can also be mixed with water and applied through the pitcher. It is a most efficient technique for perpetual supply of water in the soil, minimizing evaporation losses and risk of salinization. Twenty such pitchers were placed adjacent to growing plants in different areas on the site. However, the experiment was not successful due to the theft of the pitchers placed for the experiment.

**Pitcher irrigation**

## MAJOR ACHIEVEMENTS

**Table 7: Plantation carried out during three years**

| Sl. No. | Species | | Years of plantation with quantity | | | | Total |
|---|---|---|---|---|---|---|---|
| | | | 2011 | 2012 | 2013 | 2014 | |
| 1. | *Dalbergia sissoo* | Shisham | 150 | 920 | 900 | 400 | 2370 |
| 2. | *Albizia lebbeck* | Kala siris | - | 550 | 350 | - | 900 |
| 3. | *Albizia procera* | Siris | - | 500 | - | - | 500 |
| 4. | *Pongamia pinnata* | Karanj | - | 35 | 50 | 100 | 185 |
| 5. | *Bauhinia variegata* | Kachnar | - | 200 | 500 | - | 700 |
| 6. | *Emblica officinalis* | Aonla | - | 500 | 500 | 200 | 1200 |
| 7. | *Mangifera indica* | Aam | - | 20 | 40 | - | 60 |
| 8. | *Psidium guajava* | Amrud | - | 50 | 40 | - | 90 |
| 9. | *Syzygium cumini* | Jamun | - | 21 | 40 | 20 | 81 |
| 10. | *Azadirachta indica* | Neem | 300 | - | 50 | | 350 |
| 11. | *Artocarous heterophyllus* | Kathal | - | 20 | 40 | - | 60 |
| 12. | *Madhuca indica* | Mahua | 300 | - | 10 | - | 310 |
| 13. | *Zizyphus sp.* | Ber | 150 | | 450 | - | 600 |
| 14. | *Aegle marmelos* | Bael | - | 400 | 200 | | 600 |
| 15. | *Cassia fistula* | Amaltas | - | - | - | 100 | 100 |
| 16. | *Asparagus racemosus* | Satavar | - | - | 50 | - | 50 |
| 17. | *Rauvolfia serpentina* | Sarpgandha | - | - | 50 | - | 50 |
| 18. | *Tamarindus indica* | Imli | - | - | - | 100 | 100 |
| 19. | *Bombax ceiba* | Semal | - | - | - | 100 | 100 |
| 20. | *Bamboo sp.* | Bamboos | - | 1035 | 1800 | 1000 | 3835 |
| **Total** | | | | | | | **12,241** |

**1. Identification of the best suitable species:** On the basis of growth and survival and subsequent establishment in the project site some species have been identified for their use in future ecological restoration program. Even grass species have been identified which have a potential for establishment in mine spoils.

**Table 8: Potential species based on survival percentage**

| **Tree** | |
|---|---|
| 1 | *Pongamia pinnata* |
| 2 | *Albizia procera* |
| 3 | *Dalbergia sissoo* |
| 4 | *Psidium gaujava* |
| 5 | *Embilica officinalis* |
| 6 | *Albizia lebbeck* |
| 7 | *Bauhinia variegata* |
| 8 | *Mangifera indica* |
| 9 | *Artocarpus hetrophyllus* |
| **Bamboo** | |
| 1 | *Dendrocalamus strictus* |
| 2 | *Dendrocalamus asper* |
| 3 | *Bamboosa bambos* |

| **Shrubs** | |
|---|---|
| 1 | *Dodonaea viscosa* |
| 2 | *Vitex negundo* |
| 3 | *Agave sislana* |
| **Grasses** | |
| 1 | *Pennisetum pedicellatum* |
| 2. | *Pennisetum purpureum* |
| 3 | *Cymbopogon martini* |
| 4 | *Cenchrus ciliaris* |
| 5 | *Cenchrus setigerus* |
| 6 | *Arundo donax* |
| **Herbs** | |
| 1 | *Crotolaria juncea* |
| 2 | *Styllosanthes hamata* |

***Albizia lebbeck* (Kala sirus)**

***Bauhinia variegata*** (Kachnar)

***Albizia procera* (Sirus)**

***Pongamia pinnata* (Karanj)**

***Dalbergia sissoo*** **( Shisham)**

***Emblica officinalis*** **(Aonla)**

***Mangifera indica* (Aam)**

***Syzygium cumini* (Jamun)**

***Azadirachta indica* (Neem)**

**2. Success of horticultural species:** An experimental plantation of some horticultural species native to the area was done. The horticultural species were selected so that the local inhabitants could derive benefits from it in long term. All the tried species were found to be adaptive in the site condition though the growth was slow. However, *Emblica officinalis, Mangifera indica Syzygium cumini* and *Psidium guajava* proved to be more successful in comparison to *Artocarpus heterophyllus* and *Aegle marmelos*.

**3. Grass production:** The project site before the initiation of ecological restoration was completely devoid of grass cover. But with the initiation of ecorestoration, grasses have slowly colonized the project site. *Pennisetum pedicellatum*, being the first to colonize the site. Later on, the grass seeds broadcasted in the area began to germinate and established well in the project site. Grasses like *Pennisetum purpureum, Arundo donax, Cymbopogon martini* which were carried all the way from F.R.I., Dehradun were propagated by means of culms and root slips have established well in the site. Grass plays an important ecological role besides catering the fodder resource needs of the villagers. The villagers from the adjoining villages have already begun collecting grasses as fodder resource from the project site.

**Site covered with grass**

**Villagers collecting grass from the site**

**4. Nutrients status:** Notable changes have taken place in the nutrient status of the project site in the span of three years. The pH of the site has changed from 6.0 to 7.14 after the restoration work. Similarly, organic carbon content has increased from 0.63 % to 0.92 %. The nitrogen content too has increased from 0.005% to 0.014 %. However, there has been decrease in the available phosphorus and potassium from 0.66 % to 0.002 % and 0.053 % to 0.012 % respectively. Similar negative change has also been reported in other studies carried out on the impact of plantation on coal mine soil characteristics.

**Table 8: Chemical properties of the soil in the project site**

| **Chemical properties** | | | | | |
|---|---|---|---|---|---|
| | **pH** | **Organic carbon (%)** | **Available Nitrogen %** | **Available Phosphorus %** | **Available Potassium %** |
| Before restoration | 6.0 | 0.63 | 0.005 | 0.66 | 0.053 |
| After restoration | 7.14 | 0.92 | 0.014 | 0.002 | 0.012 |

**Attraction of fauna:**

The once degraded and inhabitable area have now been completely covered by trees, shrubs, herbs, which have started attracting birds, insect, reptiles, and even animals. The presence of different birds and butterflies can be seen in the early morning, while jackals can be seen in the evening.

**Cuckoo (Bird)**

**Garden lizard (Reptiles)**

**Butterfly on the flowers of *Vitex negundo***

**Jackal in the restored site (Animal)**

# An Overview of the project site after ecological restoration

**Process of community development on OB dumps**

**Vegetation cover on OB dumps**

**Diverse vegetation cover on OB Dumps**

## Description, distribution, habitat, propagation and uses of species used in the ecological restoration of Tetulmari mined out area

### FORESTRY SPECIES

**Botanical Name:** ***Albizia lebbeck***
**Common Name: Kala siris**
**Family: Fabaceae**
**Description, distribution and habitat:**
It is a large erect deciduous tree upto a height of 30 m. the crown is spreading with clear bole upto 6-9 m. Bark is dark grey with irregular cracks on it. Leaf rachis is 12-15 cm long and stout, pinnae 2- 6 pairs 10-15 cm long. Flowers are greenish white, fragment in short corymbose racemes. Trees flowers during April-May and fruiting occurs during October-November. It is native to Pakistan, India, Bangladesh, the Andaman Islands, Burma, S China, NE Thailand, and Malaysia; possibly also Sri Lanka, the eastern islands of Indonesia, Africa and N. Australia.

**Propagation Method**
Propagation by seeds (8,000-10,000 / kg) or cuttings, or coppicing. Seeds are liable to attacks by weevils and other insects; however, this may be prevented to some extent by early harvesting. Seed treatment by boiling water and subsequent soaking, as for acacias.

**Functional Uses and Services:**
A nitrogen-fixing tree, with value for shade, quality hardwood (cabinet, veneer, construction), fuel-wood and charcoal, and honey (source of nectar and pollen); proposed as an alternative forage to *Leucaena leucocephala* in more acid soils, particularly with the advent of the *leucaena psyllid* (*Heteropsylla cubana*), but to date has not been adopted commercially to any extent. The extensive, shallow root system makes it a good soil binder and suited to soil conservation and erosion control. Various parts of the tree are used in folk remedies for many ailments. It is also used as an ornamental and avenue tree, and sometimes as a shade tree in coffee and tea. The bark contains saponins and tannins, used for making soap and in tanning, respectively

**Botanical Name:** ***Albizia procera***
**Common Name: Red siris; safed siris**
**Family: Fabaceae**
**Description, distribution and habitat:**

It is a fast-growing, semi-deciduous, light-demanding and fairly drought-tolerant species. It occurs naturally in a wide distribution from India and Myanmar through South-East Asia to Papua New Guinea and northern Australia. It extends north into China, including Hainan and Taiwan. In India, *A. procera* occurs in tropical semi-evergreen forests, tropical moist deciduous forests, dry tropical forests such as low alluvial savannah woodlands and northern subtropical broadleaved forests. In Vietnam, it is found in tropical rain forest, dry open forest and savannahs.

**Propagation Method:** *A. procera* can be propagated quite successfully by stumps and stem or root cuttings provided that this is not done during the peak of the rainy or the dry season. Vegetative propagation also occurs through layering. Root suckers are readily produced when roots are exposed.

**Functional Uses and Services:** *Albizia procera* is a useful tree for farm and amenity planting, light shade, firebreaks and for the rehabilitation of seasonally dry, eroded and degraded soils. *A. procera* is regarded as a soil improver and is used as a nurse tree in tea gardens, coffee and cocoa plantings. *A. procera* is widely planted for its good soil-binding capacity. The bark can provide tanning material. It is used in India for tanning and dyeing. All parts of the plant are reported to show anti-cancer activity. The roots contain alpha-spinasterol and a saponin that has been reported to possess spermicidal activity at a dilution of 0.008%. *A. procera* is commonly used in traditional medicines.

**Botanical Name:** ***Bauhinia variegata***
**Common Name: Kachnar**
**Family: Caesalpiniaceae**
**Description, distribution and habitat:**

*Bauhinia variegata* is a small to medium-sized deciduous tree with a short bole and spreading crown, attaining a height of up to 15 m and diameter of 50 cm. In its natural habitat in India, the tree is deciduous, remaining leafless from Jan-Feb to April with leaf fall in Nov-Dec. Flowering occurs when the plant is leafless. Tree starts flowering at very early age of 2-3 years. It is capable of growing on a wide range of soils from gravely, shallow, rocky soil on hills slopes to sandy loam and loamy soil in the valley, spread throughout India, except Jammu and Kashmir, Himachal Pradesh, Sikkim.

**Propagation Method:** Seeds germinate readily. Orchid tree can also be propagated from cuttings of semi ripe wood taken in summer and rooted over bottom heat. Branches can be induced to grow roots if they are layered, either by burying a section in the ground, or scarring a small section and then wrapping it with damp sphagnum moss and enclosing in a plastic bag. The tree sometimes produces suckers which can be dug up and replanted.

**Functional Uses and Services**

The tree is used as a street tree, shade tree, specimen or focal tree in tropical and subtropical landscapes. It can be used in cough conditions, asthma, abdominal distention also acts as a gargle for sore throats, prevent from skin diseases, or internally as a remedy for diarrhoea. It is helpful in managing skin discoloration, veiling, baldness, conditions involving bilious. Bark is alterative, anthelmintic, astringent and tonic. Paste of the bark is useful in the treatment of cuts and wounds, skin diseases, scrofula and ulcer. The dried buds are used in the treatment of piles, dysentery, diarrhoea and worms.

**Botanical Name:** ***Dalbergia sissoo***
**Common Name: Shisham**
**Family: Fabaceae**

**Description, distribution and habitat:**

It is the state tree of Punjab state (India) and the provincial tree of Punjab province (Pakistan). It is primarily found growing along river banks below 900 meters (3,000 ft) elevation, but can range naturally up to 1,300 m (4,300 ft). The temperature in its native range averages 10–40 °C (50–104 °F), but varies from just below freezing to nearly 50 °C (122 °F). It can withstand average annual rainfall up to 2,000 millimeters (79 in) and droughts of 3–4 months. Soils range from pure sand and gravel to rich alluvium of river banks; shisham can grow in slightly saline soils.

**Propagation Method:**

Propagation is easy, either by seeds, cuttings or suckers, the tree coppices and suckers profusely and is amenable to pruning, trimming and thinning. Seedlings and young trees are demanding in light but sensitive to wild fires.

**Functional Uses and Services**

Wood quality is high (rose wood), the heartwood is dark golden brown, oily and heavy, very durable and very resistant to termites. The oil from the wood is stable at high temperatures hence used for lubricating heavy machinery. The tree is very effective in controlling gully erosion. *D. sissoo* is utilized in combination with a variety of crops, and as a shade tree for cash crops such as tea. It is also appreciated by bees and the source of a variety of medicinal products.

**Botanical Name:** ***Pongamia pinnata***
**Common Name: Karanj**
**Family: Fabaceae**
**Description, distribution and habitat:**

It is a fast-growing evergreen tree which reaches 40 feet in height and spread, forming a broad, spreading canopy casting moderate shade. It is widely distributed in tidal and beach forests of India.

**Propagation Method:**
Seeds, remaining viable for some time, require no special scarification. Direct sowing is usually successful. Seedlings transplant easily from the nursery after about a year. Root suckers are rather plentiful as well. It is a rapid-growing coppice species that can be cloned.

**Functional Uses and Services**
Pongamia seeds and oil is anthelmintic, styptic, and depurative. It is useful in rheumatism arthritis, whooping cough, skin ailments and scabies. Seed oil is mainly used in cosmetics, in soap making and as a lubricant. Seed oil is also used as insecticidal, nematicidal and bactericidal. Flowers are useful to quench dipsia in diabetes and for alleviating vata and kapha. Leaves are digestive, laxative and useful in flatulence, dyspepsia, diarrhea, leprosy and cough. Bark is anthelmintic and used in pesticides. Dried leaves are used in stored grains to repel insects. The bark also yields a black gum that is used to treat wounds caused by poisonous fish.

**Botanical Name:** ***Terminalia arjuna***
**Common Name: Arjun**
**Family: Combretaceae**
**Description, distribution and habitat:**

The arjuna tree is about 20–25 metres tall; usually has a buttressed trunk, and forms a wide canopy at the crown, from which branches drop downwards. The arjuna tree is usually found growing on river banks or near dry river beds in West Bengal and south and central India. Common in almost every part of India. Grows well along bank of

streams, rivers, ravines, dry water courses, reaching very large sizes on fertile alluvial loam.

**Propagation Method**

It can be artificially propagated through seeds, coppicing, pollarding, root-suckers, stumps and air-layering. It is initially slow-growing but later fast-growing. It attains 2–3 m height in 3 years.

**Functional Uses and Services**

The bark is astringent, sweet, acrid, cooling, aphrodisiac, cardiotonic, urinary astringent, expectorant, alexiteric and is useful in fractures, ulcers, cirrhosis of the lever, hyperhidsis, otalgia and hypertension. A decoction of the bark is used as wash in ulcers. It improves cardiac muscle function and pumping action of the heart.

**Botanical Name:** ***Cassia fistula***
**Common Name: Amaltas**
**Family: Fabaceae**
**Description, distribution and habitat:**

The golden shower tree is a medium-sized tree, growing to 10–20 m (33–66 ft) tall with fast growth. It grows well in dry climates. Growth for this tree is best in full sun on well-drained soil; it is relatively drought tolerant and slightly salt tolerant. It will tolerate light brief frost, but can get damaged if the cold persists. It can be subject to mildew or leaf spot, especially during the second half of the growing season. The species is native to the Indian subcontinent and adjacent regions of Southeast Asia. It ranges from southern Pakistan eastward throughout India to Myanmar and Thailand and south to Sri Lanka.

**Propagation Method:** *Cassia fistula* can be propagated by seed and vegetatively through cuttings and layering. The seeds have a hard seed coat and germination is improved by mechanical scarification or treatment with concentrated sulphuric acid for at least 45 minutes. Seed can be stored for prolonged periods without loss of viability. *Cassia fistula* seed should be sown in full light, and adequate water supply is required for optimal germination. The seed can increase three times in weight by absorbing water. Direct sowing is practiced in Asia.

**Functional Uses and Services:** The tree is planted throughout the tropics for its ornamental and medicinal properties. There are many medicinal uses for *C. fistula* known from Asia. The flesh of the fruit is used as a laxative, while the bark can be used to treat skin infections.

**Botanical Name:** ***Melia azaderach***
**Common Name: Bakain**
**Family: Meliaceae**
**Description, distribution and habitat:**

It is a deciduous tree. The adult tree has a rounded crown, and commonly measures 7–12 metres (20–40 ft) tall; however in exceptional circumstances *M. azedarach* can attain a height of 45 metres (150 ft). It tolerates a broad range of climatic and soil conditions. Young trees are vulnerable to frost but older trees resist frosts. Older trees can tolerate mean maximum temperature of the hottest month of 39°C and mean minimum temperature of the coldest month of -5°C. This species is drought hardy. It is native to China, Japan, the Indian sub-continent, south-eastern Asia and large parts of northern and eastern Australia.

**Propagation Method:** It can be propagated easily through seeds or root cuttings. The plant reaches maturity in 6-10 years time and can develop seeds that are viable. The seeds of the plant can be viable for number of years. No pre-sowing treatment is required if propagated through seeds.

**Functional Uses and Services**

The main utility is its timber.

**Botanical Name:** ***Madhuca indica***
**Common Name: Mahua**
**Family: Sapotaceae**
**Description, distribution and habitat:**

Mahua is a tropical deciduous fast-growing tree that grows to 20 meters in height and possesses evergreen or semi-evergreen foliage. It is cultivated in warm and humid regions for its oleaginous seeds, flowers and wood. It is adapted to arid environments, being a prominent tree in tropical mixed deciduous forests in India in the states of West Bengal, Chhattisgarh,

Jharkhand, Uttar Pradesh, Bihar, Maharashtra, Madhya Pradesh, Kerala, Gujarat and Orissa. The tree grows on a wide variety of soils but thrives best on sandy soil. The species is drought-resistant, strong light demander and readily suppressed under shade. It is not frost-hardy. It also grows on shallow, bouldery, clayey and calcareous soils.

**Propagation Method:** Seeds are sown during June-August. Seeds do not need any treatments. Germination gets completed 3 weeks and then planting of seedlings is done in dry and moist tropics in July.

**Functional Uses and Services**

The fat is used for the care of the skin, to manufacture soap or detergents, and as a vegetable butter. Outer fruit coat is eaten as a vegetable and the fleshy cotyledons are dried and ground into a meal. The product is often used in sweets and chocolates under the name "illipe". The seed cakes obtained after extraction of oil constitute very good fertilizer. The flowers are used to produce an alcoholic drink in tropical India. Several parts of the tree, including the bark, are used for their medicinal properties. It is considered holy by many tribal communitites because of its usefulness.

**Botanical Name:** ***Tamarindus indica***
**Common Name:** Imli
**Family:Fabaceae**
**Description, distribution and habitat:**

The tamarind is a long-lived, medium-growth, bushy tree, which attains a maximum crown height of 12 to 18 metres (40 to 60 feet). The crown has an irregular, vase-shaped outline of dense foliage Tamarind is native to tropical Africa, where it grows wild throughout the Sudan. It has been so long ago introduced into India that it has often been reported as indigenous there also. . The tree grows well in full sun in clay, loam, sandy, and acidic soil types, with a high drought and aerosol salt (wind-borne salt as found in coastal areas) resistance.

**Propagation Method:** Seeds can be scarified or briefly boiled to enhance germination. They retain germination capability after several months if kept dry.

**Functional Uses and Services**

In culinary it is used as pickling agent, the pulp is edible. In traditional medicine, throughout Southeast Asia, fruit of the tamarind is used as a poultice applied to foreheads of fever sufferers. Carpentary uses, Tamarind wood are a bold red color. Due to its density and durability, tamarind heartwood can be used in making furniture and wood flooring.

## HORTICULTURAL SPECIES

**Botanical Name:** ***Mangifera indica***
**Common Name: Mango**
**Family: Anacardiaceae**
**Description, distribution and habitat:**

The Mango tree is erect, 30 to 100 ft (roughly 10-30 m) high, with a broad, rounded canopy which may, with age, attain 100 to 125 ft (30-38 m) in width, or a more upright, oval, relatively slender crown. Flowering occurs in March and Early April. It is native to southern Asia, especially eastern India, Burma, and the Andaman Islands.

**Propagation Method:** Seeds and grafting. Due to recalcitrant nature of the seeds, they have a short viable life, cannot be dried well and cannot withstand low temperatures.

**Functional Uses and Services**

Mango kernel decoction and powder (not tannin-free) are used as vermifuges and as astringents in diarrhoea, hemorrhages and bleeding hemorrhoids. The fat is administered in cases of stomatitis. Extracts of unripe fruits and of bark, stems and leaves have shown antibiotic activity

A somewhat resinous, red-brown gum from the trunk is used for mending crockery in tropical Africa. In India, it is sold as a substitute for gum arabic.

Dried flowers are of medicinal value and used for curing dysentery and cataract of bladder. It is a cure for wasp sting, rubbed between hands and left to dry.

Mango fruit is one of the delicious fruit of India exported to many countries. The green unripe fruits are used in curries, sharbats and pickles.

**Botanical Name:** ***Emblica officinalis***
**Common Name: Indian gooseberry, Amla,**
**Family: Phyllanthaceae**

**Description, distribution and habitat:**

The tree is small to medium in size, reaching 8 to 18 m in height, with a crooked trunk and spreading branches. The flowering occurs in June-July. This can be found in warmer, tropical areas in India, specifically in coastal areas and Kashmir and also across the country at an elevation up to 1, 500 meters.

**Propagation Method**

They are raised through seeds as well as inarching. However, there is prolonged juvenility and wide variability in seedlings. On the other hand only limited number of scion shoots is available for inarching owing to upright tree habit. It can also be propagated through patch/ modified ring budding in north India during mid May to September with 60-100% success. Besides, Veneer grafting also has successfully been attempted. Considering the efficiency and requirement of single bud, budding is an ideal method of propagation. Six months to one year-old seedlings obtained from ordinary seedlings amla trees are being used as rootstock. Mature amla fruits are collected during January-February and their seeds are extracted after drying. Seeds are sown in raised beds April onwards and these are transplanted in separate bed for subsequent budding.

**Functional Uses and Services**

The fruits are not good for fresh consumption because of astringency and acidic taste. These fruits are used in huge quantities for making pickles and preserves, both in the villages and in the towns.

**Botanical Name:** ***Psidium guajava***
**Common Name: Guava, lemon guava**
**Family: Myrtaceae**

**Description, distribution and habitat:**

A small tree to 33 ft (10 in) high, with spreading branches, the Guava is easy to recognize because of its smooth, thin, copper-colored bark that flakes off, showing the greenish layer beneath and also because of the attractive, "bony" aspect of its trunk which may in time attain a

diameter of 10 in (25 cm. it grows at an altitude of 0 to 1500 m above the sea level. It can be found in many tropical and sub tropical areas of the world.

**Propagation Method:** This reproduces mainly by seed, but it can also reshoot from stumps and produce suckers from near the base of the trunk. The seeds are mainly dispersed by fruit-eating birds and bats, as well as other animals and people.

**Functional Uses and Services:** *Psidium guajava* is grown for its fruit which upon ripening, the guava becomes soft and juicy. It may be eaten fresh, made into a juice or nectar contain fruit pulp, or made into preserves, jam, jelly, or paste. Guava is an excellent source of vitamin C. Its wood can be used to make poles, fence-posts and tool handles, in handicrafts and for charcoal and firewood.

**Botanical Name:** ***Syzygium cumini***
**Common Name: Jamun**
**Family: Myrtaceae**
**Description, distribution and habitat:**

A slow growing species, it can reach heights of up to 30 m and can live more than 100 years. Its dense foliage provides shade and is grown just for its ornamental value. At the base of the tree, the bark is rough and dark grey, becoming lighter grey and smoother higher up. Trees start flowering from March to April. It is native to Bangladesh, India, Nepal, Pakistan, Sri Lanka, Malaysia, the Philippines, and Indonesia

**Propagation Method:** Direct sowing of seeds.
**Functional Uses and Services:**Fruits have some of the highest levels of natural folic acid and recommended for pregnant women. Powdered seeds consumed to control diabetes.

**Botanical Name:** ***Zizyphus jujuba***
**Common Name: Red date, Chinese date , Indian date**
**Family: Rhamnaceae**
**Description, distribution and habitat:**

*Ziziphus jujuba* is a deciduous Tree growing to 10 m (32ft) by 7 m (23ft) at a fast rate. It is in flower from Apr to May, and the seeds ripen in October. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Insects.The plant is self-fertile. Its precise natural distribution is uncertain due to extensive

cultivation, but is thought to be in southern Asia, between Lebanon, Iran, Pakistan, India, Bangladesh, Nepal (called Bayar), the Korean peninsula, and southern and central China, and also southeastern Europe though more likely introduced there.

**Propagation Method:** Seed - best sown in a cold frame as soon as it is ripe. Stored seed requires 3 months warm then 3 months cold stratification. Germination should take place in the first spring, though it might take another 12 months. Prick out the seedlings into individual pots when they are large enough to handle and grow them on in a cold frame for at least their first winter. Plant out in early summer. Root cuttings in a greenhouse in the winter. Best results are achieved if a temperature of 5 - 10°c can be maintained. Cuttings of mature wood of the current season's growth, November to January in a frame. Division of suckers in the dormant season. They can be planted out direct into their permanent positions if required.

**Functional Uses and Services:** Zizyphus is used for improving muscular strength and weight, for preventing liver diseases and stress ulcers, and as a sedative. Jujube is also used for various skin conditions including dry and itchy skin, purpura, wounds, and ulcers; digestive problems including lack of appetite and diarrhea; and circulatory problems including high blood pressure and anemia. Other uses are for fatigue, hysteria, fever, inflammation, asthma, and eye diseases.

**Botanical Name:** ***Aegle marmelos***
**Common Name: Bael**
**Family: Rutaceae**
**Description, distribution and habitat:**

It has a reputation in India for being able to grow in places that other trees cannot. It copes with a wide range of soil conditions (pH range 5-10), is tolerant of water logging and has an unusually wide temperature tolerance (from -7 °C to 48 °C). It requires a pronounced dry season to give fruit. It occurs in dry forests on hills and plains of northern, central, eastern and southern India, Pakistan, southern Nepal, Sr Lanka, Myanmar, Bangladesh, Vietnam, Laos, Cambodia and Thailand. It is cultivated throughout India, as well as in Sri Lanka, the northern Malay Peninsula, Java, the Philippines, and Fiji.

**Propagation Method:** Bael is usually propagated by seeds. The seeds are recalcitrant and cannot be stored for longer periods under normal storage conditions.

**Functional Uses and Service:** Ripe bael fruit has been traditionally used as a well-known laxative**,** treating constipation; however, the unripe fruit is also a common remedy for diarrhoea and dysentery, inhibiting intestinal motility and having also documented gastro protective effects.

**Botanical Name:** ***Artocarpus heterophyllus***
**Common Name: Kathal**
**Family: Moraceae**
**Description, distribution and habitat:**
Jackfruit can grow up to 9-21 m (70 ft) tall, with evergreen, alternate, glossy and leathery leaves to 22.5 cm (9 in) in length. They are vegetated in other parts of India, South-east Asia, East Indies, Philippines, Brazil and Surinam also.

**Propagation :** Usually by seeds which germinate in 1-8 weeks. Air- layering and grafting is done to propagate also.

**Functional Uses and Service:** Jackfruit is commonly used in South and Southeast Asian cuisines. The leaves of jackfruit tree are useful for curing fever, boils and skin diseases. When heated, they prove useful in curing wounds. The latex of the fruit is helpful in treating dysopia, opthalmities and pharyngitis. The latex can also be mixed with vinegar to heal abscesses, snakebites and glandular swellings. The wood of jackfruit tree is widely used in manufacturing musical instruments, furniture, doors, windows and roof constructions. The seed starch is useful in relieving biliousness, while the roasted seeds are regarded as aphrodisiac. To heal ulcers, the ash of jackfruit leaves is burnt with corn and coconut shells and used either alone or mixed with coconut oil. The root of jackfruit tree forms the remedy for skin diseases, fever and diarrhea. The heartwood of the tree is used by Buddhist forest monastics in Southeast Asia, for dying the robes of the monks to light brown color.

# MEDICINAL SPECIES

**Botanical Name:** ***Azadirachta indica***
**Common Name: Neem**
**Family: Meliaceae**
**Description, distribution and habitat:**

Commonly called divine tree, the neem tree is sacred in its native India, Bangladesh and Pakistan. These fast-growing shade trees can survive drought and grow well in poor soil. And, the leaves, fruit and seeds are edible. Neem is a fast-growing tree that can reach up to 15–20 m (about 50–65 feet) tall, and sometimes even to 35–40 m (115–131 feet). It is evergreen, but in serious drought it may lose most or nearly all of its leaves. The branches are spread far apart. It is native to India, Myanmar, Bangladesh, Sri Lanka, Malaysia and Pakistan. It grows in tropical and semi-tropical regions.

**Propagation Method:**

**Seed propagation:** Neem tree seeds germinate readily and have a high germination rate, between 75 and 90 percent. The seeds germinate and emerge in 14 to 21 days. Neem seeds should be planted fresh, within four weeks of harvest, and they don't need any pretreatment before planting. Because neem seeds germinate reliably and quickly, seed planting is the most common way to propagate a neem tree. In mild climates, neem trees can self-seed at a rapid enough rates to be considered invasive in some areas.

**Planting seeds:** Plant neem seeds 1/4 to 1/2 an inch deep in individual pots filled with seed-starting mix. The seeds need a consistent temperature between 68 and 72 degrees Fahrenheit to germinate well. Mist the soil with water whenever it starts to dry out during germination and growth. You can also start seeds outdoors in a nursery bed in warm climates. Select a spot that gets dappled shade to protect the seedlings from direct sun during early growth and development. **Rooting cuttings:** Cuttings, either from the roots or new softwood growth, will produce new roots in the right environment. Cuttings need a consistent temperature of 65 to 75 F. The best way to root cuttings is in a pot filled with soilless rooting medium or sterile rooting compost. In warm climates, you can root cuttings outdoors in a nursery bed. **Shoot cuttings: Shoot** cuttings are soft, new growth taken in spring when neem trees are actively growing. Take 4-inch-long cuttings from the tip of a new branch or growth. You can pinch off the bottom leaves but leave the top set on the cutting. Shoot cuttings root best in a humid environment, like a greenhouse.

If you don't have a greenhouse, you can create a makeshift one by turning a clear plastic bag upside down over the cutting and fastening it.

**Functional Uses and Services:**

Neem is said to be antifungal,antidiabetic, antibacterial, antiviral, contraceptive and sedative. Neem products are also used in selectively controlling pests in plants. Neem is considered a large part of Ayurvedic medicine. All parts of neem are used for preparing many different medicines, especially for skin disease. Part of the Neem tree can be used as a spermicide . Neem oil is used for preparing cosmetics (soap and shampoo, as well as lotions and others), and is useful for skin care such asacne treatment. Neem oil has been used effectively as a mosquito repellent. Neem is useful for damaging over 500 types of insects, mites, ticks, and nematodes, by changing the way they grow and act. Neem does not normally kill pests right away; rather it slows their growth and drives them away. As neem products are cheap and not poisonous to animals and friendly insects, they are good for pest control

**Botanical Name:** ***Vitex negundo***
**Common Name: Sinduar**
**Family: Verbenaceae**
**Description, distribution and habitat:**

*Vitex negundo* is a deciduous shrub growing to 3 m (9ft) by 3 m (9ft) at a medium rate. It is in flower from Sep to October. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Insects. It is widely used in folk medicine, particularly in South and Southeast Asia. It is native to tropical Eastern and Southern Africa and Asia. It is widely cultivated and naturalized elsewhere. It is found near bodies of water, recently disturbed land, grasslands, and mixed open forests

**Propagation Method:** Seeds are sown in March in a greenhouse. It does not need any pre-treatment. Germination is usually free and quick. Prick out the seedlings into individual pots when they are large

enough to handle and grow them on in the greenhouse for their first winter. Plant them out into their permanent positions in early summer of the following year.

**Functional Uses and Services :** Tree extracts have been used in Ayurvedic medicine as a rejuvenative tonic for promoting virility. In Unani, the seeds are recommended for controlling premature ejaculation. Because of its anti-inflammatory, antibacterial and antifungal properties, the plant is useful in treating sores and skin infections. Five-Leaved Chaste Tree relieves muscle aches and joint pains. The herb is effective in treating vaginal discharge. It also enhances the male libido.

**Botanical Name:** ***Rauvolfia serpentina***
**Common Name: Sarpagandha**
**Family: Apocynaceae**
**Description, distribution and habitat:**
An erect perennial shrub with a long, irregularly, nodular, yellowish root stock flowering occurs from March to May. It is native to the Indian Subcontinent and East Asia (from India to Indonesia. Grows in moist shady forests in India. It is an endangered species in many parts of India

**Propagation Method :** Can be propagated both through seeds and vegetatively, but propagation by seed is preferred.

**Functional Uses and Services:** Rauvolfia preparations are used as antihypertensive and as sedative. It is also used for the treatment of various central nervous system disorders associated with psychosis, schizophrenia, insanity, insomnia, and epilepsy.

**Botanical Name:** ***Asperagus racemosus***
**Common Name: Shatavari**
**Family: Description, distribution and habitat:**
It is perennial and grows one to two metres tall and prefers to take root in gravelly, rocky soils high up in piedmont plains, at 1,300–1,400 metres elevation. . It is in flower from July to August. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils. It can grow in semi-shade

(light woodland) or no shade. It prefers dry or moist soil.

**Propagation Method:** Seed - pre-soak for 12 hours in warm water and then sow in spring or as soon as the seed is ripe in early autumn in a greenhouse. It usually germinates in 3 - 6 weeks at 25°C. Prick out the seedlings into individual pots when they are large enough to handle and grow them on in a sunny position in the greenhouse for their first winter. Plant them out into their permanent positions in late spring or early summer. Division in early spring as the plant comes into growth.

**Functional Uses and Services:** *Asparagus racemosus* (Shatavari) is recommended in Ayurvedic texts for the prevention and treatment of gastric ulcers, dyspepsia and as a galactogogue. *A. racemosus* has also been used by some Ayurvedic practitioners for nervous disorders. The roots are used in Ayurvedic medicine, following a regimen of processing and drying. It is generally used as a uterine tonic, as agalactogogue (to improve breast milk), in hyperacidity, and as a best general health tonic.

**Botanical Name:** ***Agave sislana***
**Common Name: Sisal, Rambaansa**
**Family: Agavaceae**
**Description, distribution and habitat:**

It is a species of *Agave* native to southern Mexico but widely cultivated and naturalized in many other countries. Sisal plants, *Agave sisalana*, consist of a rosette of sword-shaped leaves about 1.5–2 meters (4.9–6.6 ft) tall. Young leaves may have a few minute teeth along their margins, but lose them as they mature. The sisal plant has a 7–10 year life-span and typically produces 200–250 commercially usable leaves. Each leaf contains an average of around 1000 fibres. Commonly found on dry, permeable sandy loam and saline or red soils in low rainfall areas and on bunds, boundaries and railway embankments. It grows best in full sun light.

**Propagation Method:** Propagation of sisal is generally by using bulbils produced from buds in the flower stalk or by suckers growing around the base of the plant, which are grown in nursery fields until large enough to be transplanted to their final position. These methods offer no potential for genetic

improvement. Invitro multiplication of selected genetic material using meristematic tissue culture (MST) offers considerable potential for the development of improved genetic material.

**Functional Uses and Services:**

Traditionally, sisal has been the leading material for agricultural twine (binder twine and baler twine) because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in saltwater.

Apart from ropes, twines, and general cordage, sisal is used in low-cost and specialty paper, dartboards, buffing cloth, filters, geotextiles, mattresses, carpets, handicrafts, wire rope cores, and Macramé.

## GRASS SPECIES

**Botanical Name: *Arundo donax***
**Common Name: Narkat, Giant reed**
**Family: Poaceae**
**Description, distribution and habitat:**

It is a tall perennial cane growing in damp soils, either fresh or moderately saline. *Arundo donax* flowers in late summer, bearing upright, feathery plumes 40 to 60 centimetres (16 to 24 in) long, that are usually seedless or with seeds that are rarely fertile. *Arundo donax* is native to eastern and southern Asia, the Mediterranean Basin and probably also parts of Africa and southern Arabian Peninsula. It forms dense stands on disturbed sites, sand dunes, in wetlands and riparian habitats.

**Propagation Method:** It mostly reproduces vegetatively, by underground rhizomes. Establishment is a critical point of cultivation. Stem and rhizome have a great ability to sprout after removal from mother plant and both can be used for clonal propagation. The uses of rhizomes are found to be the better propagation method for this species, achieving better survival rate.

**Functional Uses and Services:** The rhizome can be dried and ground into powder to make bread, usually in conjunction with cereal flours. It can also be roasted or boiled as the root is diaphoretic, diuretic, emollient and galactofuge.

**Botanical Name:** ***Cymbopogon citratus***
**Common Name: lemon grass, fever grass**
**Family: Poaceae**
**Description, distribution and habitat:**

It is a tropical plant from Southeast Asia. The culms (stems) of this dense, clump-forming grass have been used in cooking and herbal medicine for centuries.

**Propagation Method:** Clumps divided into slips and planted during rains.

**Functional Uses and Services:** Its oil is yellow or amber liquid that is antiseptic; it can be used to treat athlete's foot (tinea pedia). It is used against coughing, cuts and asthma, bladder disorders. It is also used in the cosmetic industry. It can even be planted for reclamation of degraded land.

**Botanical Name:** ***Cenchrus setigerus***
**Common Name: Dhaman grass**
**Family: Poaceae**
**Description, distribution and habitat:**

It is a tuffed perennial grass growing up to 70-100 cm high with flat or folded leaf-blades, the roots having none or short rhizomes. It is native to East Africa and Western Asia and India, and has been naturalized in the dry tropics and subtropics. It grows between 30$^{o}$N and 30$^{o}$S at elevations between 500 and 800 m above sea level. It does well over a wide range of soils. While it prefers light textured sandy soils, it can be found on gravelly areas and alluvial flats and heavy black clays.

**Propagation Method:** Sowing of seeds.
**Functional Uses and Services:** The plant is used in control of soil-erosion.

**Botanical Name:** ***Cenchrus ciliaris***
**Common Name: Anjan grass**
**Family:Poaceae**
**Description, distribution and habitat:**

It is a perennial grass growing to 50 cm tall. It is distributed in hotter and drier parts of India, Mediterranean region, tropical and southern Africa, now widely introduced.

**Propagation Method:** Seeds sowing.

**Functional Uses and Services:** This highly nutritious grass is considered excellent for pasture in hot, dry areas and is valued for its production of palatable forage and intermittent grazing during droughty periods in the tropics. Yield of some strains makes it good for forage during the wet season also. The grass, fed green, turned into silage, or made into hay is said to increase flow of milk in cattle and impart a sleek and glossy appearance.

**Botanical Name:** ***Pennisetum purpureum***
**Common Name: Napier grass**
**Family: Poaceae**
**Description, distribution and habitat:**

It is a species of perennial tropical grass native to the African grasslands. It has low water and nutrient requirements, and therefore can make use of otherwise uncultivated lands. It is tall and forms in robust bamboo-like clumps. Native to subtropical Africa (Zimbabwe) and now introduced into most tropical and subtropical countries. It grows best in high rainfall area, though it can survive in drought. It grows best in deep fertile soils.

**Propagation Method:** Napier can be propagated through seeds, however as seed production is inconsistent, collection is difficult. Alternatively, it can be planted through stem cuttings of the stolons. The cuttings can be planted by inserting them along furrows 75 cm apart, both along and between rows.

**Functional Uses and Services:** It is one of the most valuable forage, soilage and silage crops in the wet tropics.

**Botanical Name:** ***Panicum maximum***
**Common Name: Guinea grass**
**Family: Poaceae**
**Description, distribution and habitat:**

Guinea grass is a tuffed perennial with 30 mm leaf blades. The inflorescence is an open panicle. The grass is highly palatable and favoured by all grazing herbivores. It is indigenous to Africa; introduced, cultivated and now naturalized in many tropical and subtropical areas of the world. It is found in damp places with fertile soil, especially in the shade of trees along rivers. It also utilizes a variety of other growing conditions.

**Propagation Method:** Seed sowing, although plants seed readily, heads ripen very unevenly and shatter readily. Hence seed must be hand-collected. Viability of fresh seed is comparatively low. It is increased by storing seeds dry for 6 months or longer. Seed viability under natural conditions is short-lived.

**Functional Uses and Services:** Guinea grass is probably the most valuable grazing grass in its area of distribution. It is particularly palatable, delivers a high leaf production and usually occurs in abundance in good yield. The spikelets are very popular amongst seed-eating birds.

**Botanical Name:** ***Pennisetum pedicellatum***
**Common Name: Deenanath grass**
**Family: Poaceae**
**Description, distribution and habitat:**

A tall, annual, bunch grass, up to 1 m high, branched from the base and above, leafy. Leaves are 15-25 cm long by 4-10 mm wide, flat, glabrous. It is native of north tropical Africa and India. In Bihar, India, it grows on a rainfall of 127 mm between June and September, from which it can grow and produce seeds. It does best on fertile, loamy soils but, with manuring, can grow in sandy soils. It can tolerate both acidic and alkaline soils.

**Propagation Method:** Seeds

**Functional Uses and Services:** In India it is a valuable grazing grass for sheep, goats and cattle. It is also good as a short-term lay and soil stabilizer.

## Shrub species

**Botanical Name:** ***Dodonaea viscosa***
**Common Name: Vilayti mehndi**
**Family: Sapindaceae**
**Description, distribution and habitat:**

*D. viscosa* is an erect to spreading shrub growing from 1.5 to 4 metres tall. The leaves are sticky leathery. The foliage is evergreen, with the leaf shape usually spatulate (spoon-shaped). This species prefers well-drained soils and requires a well-lit area. It can tolerate part shade but the capsules will not be as spectacular in colour if shaded. This species can tolerate dry conditions and can also handle some frosts. Little maintenance is necessary. However, regular tip pruning will promote growth and branching. It has cosmopolitan distribution in tropical, subtropical and warm temperate regions of Africa, America, southern Asia and Australasia.

**Propagation Method:** *Dodonaea viscosa* can be easily propagated from both cuttings and seeds. Cuttings are often preferred to guarantee a female plant with the colourful capsules. The optimum cutting material is young growth that has just firmed. It is best to then use a rooting hormone. Straight perlite may be used as the medium or as a mixture with peat or coconut fibre. If seeds are used for propagation a treatment of soaking in very hot water prior to sowing will assist germination

**Functional Uses and Services:** The leaves are anodyne, astringent, diaphoretic, febrifuge odontalgic and vulnerary. They are applied internally in the treatment of fevers. Externally, they are used to treat toothache, sore throats, wounds, skin rashes and stings. The leaves are apparently effective in the treatment of toothache if they are chewed without swallowing the juice. The bark is employed in astringent baths and poultices. The leaves contain up to 18% tannin. Plants are very tolerant of pruning and make a good hedging plant for windy sites. Wood - heavy, tough, resistant. Used for wedges, hammers, turnery, inlay, cabinets etc.

# Bamboo species

**Botanical Name:** ***Dendrocalamus strictus***

**Common name: Calcutta bamboo**

**Family: Poaceae**

**Description, distribution and habitat:**

This species occupies 53 per cent of total bamboo area in India. Widely distributed in India in semi dry and dry zone, along plains and hilly tracts usually up to an altitude of 1000 m., also commonly cultivated throughout the plains and foot hills. They are also growing in other part of Asia and Latin America. *D. strictus* is widely adaptable to temperatures as low as -5 $^{o}$C and as high as 45 $^{o}$C. This species is mainly found in drier open deciduous forests in hill slopes, ravines and alluvial plains. It prefers well-drained, poor, coarse, grained and stony soils. It occurs naturally in tracts receiving as low as 750 mm of rainfall and also in extensive gregarious patches or as an understorey in mixed forests.

**Propagation method:** Seeds and culms**.** Vegetative propagation.

**Functional Uses and Services:** This species is one of the two most important bamboos because of it thick wall and able to take in nail without splitting the bamboo. It actually can be work like the wood. It is found suitable for reclamation of ravine land. It is extensively used as raw material in making bamboo furniture, paper mills and also for a variety of purposes such as construction, agricultural implements, musical instruments, furniture etc. Young shoots are commonly used as food. Decoction of leaves and nodes and silicious matter is used in the traditional medicine.

**Botanical Name:** ***Dendrocalamus asper***
**Common name: Giant bamboo**
**Family:Poaceae**
**Description, distribution and habitat:**

*Dendrocalamus asper* is a giant tropical and subtropical dense clumping species native to Southeast Asia. This bamboo variety of the *Dendrocalamus* genus grows 15–20 metres tall, and 8–12 cm in diameter. It is found commonly in India, Sri Lanka, and other neighboring countries. Planted or naturalized from low elevations up to 1,500 m. Dendrocalamus asper thrives best at 400-500 m altitude in areas with average annual rainfall of about 2,400 mm. They grow well on various soil types, even on sandy and rather acidic soils.

**Propagation method:** Seeds and culms**.** Vegetative propagation.

**Functional Uses and Services:** It is used as a building material and structural timber for heavy construction such as houses and bridges. The culm internodes used as containers for water and other fluids, and as cooking pots. This bamboo is also used for making laminated boards, furniture, musical instruments, chopsticks, household utensils and handicrafts. Young shoots are sweet and considered a delicious vegetable.

**Botanical Name: Bambusa bambos**
**Common name: Giant thorny bamboo**
**Family: Poaceae**
**Description, distribution and habitat:**

It grows in erect clumps upto 20-35 m high there are 1-3 spines in each branch node. It is a species of clumping bamboo native to southern Asia (India, Bangladesh, Sri Lanka, Assam, Indo-china). It is also naturalized in Seychelles, Central America, West Indies, Java, Malaysia, Maluku, Philippines

It prefers a humid tropical climate and grows best along river banks or river valleys with a rich, moist soil. It

reaches its best development in moist deciduous forests up to an altitude of 1,250 m and receiving nearly 2,000-2,500 mm rainfall a year. In flat alluvial soil, the culms are reported to attain a height of 25-30 m and a diameter of 20-25 cm.

**Propagation method:** Seeds and culms**.** Vegetative propagation.

**Functional Uses and Services:** Culms are used for house construction, scaffolding, rafters, thatching and roofing, handicrafts and art objects, basket making, bows and arrows, furniture, floating timber and rafting, cooking utensils and fencing. The raw material of this bamboo is also an important source for paper pulp and panel products. Shoots and seeds are edible and leaves are used as fodder and medicine.

## VISITS TO THE ECOLOGICAL RESTORATION SITE

This ambitious project had become the talk of the town ever since its initiation three years ago. Everyone's attention was drawn towards the ecological restoration project at Tetulmari OB dump. Some were even apprehensive about it's success in near future. Hence, regular visits to the site had become a daily routine for the officials of BCCL. However, there were important visits to the site by some experts, technocrats, scientists from various governmental organizations. The important visits were as following:

### 1. Visit of Expert Appraisal Committee, MoEF

The Expert Appraisal Committee from MoEF, visited the Ecological restoration site to assess the progress of the eco-restoration work at Tetulmari OB dump. The scientists from Forest Research Institute made several onsite demonstrations of Ecological restoration, which included oral presentation as well as poster presentation. The scientists also apprised about the activities as well as the progress of work to the committee members, who also appreciated the work being carried out on the site.

**FRI Scientists explaining the concept of ecological restoration to the EAC members**

**2. Visit of the Chairman, Coal India Limited**.

The Chairman of Coal India Limited, Mr. S. Narsing Rao , along with other dignitaries paid a visit to the Ecological restoration site at Tetulmari OB dumps to assess the progress of the highly anticipated Model ecorestoration project.

**Fri scientists apprising the success of project to the Chairman, Coal India Limited during his visit to the project site**

**3. Visit of the Director, Forest Research Institute, Dehradun**

The Director, Forest Research Institute, Dehradun visited the site on 6th June, 2014 to inspect the progress of the ecological restoration work at Tetulmari, Sijua, Dhanbad. He appreciated the work and made important observations and even suggested future course of work that could enhance the biodiversity of the project site.

**Dr. P.P. Bhojvaid, Director, F.R.I along with BCCL officials and FRI scientists in the project site**

## RECOMMENDATIONS FOR ENHANCEMENT OF BIODIVERSITY

A project of such magnitude and importance truly requires patience and hard work on the part of the executing agency as well as the project proponent. Though a good amount of work has been carried out, still there is ample scope for enhancing the biodiversity and their conservation thereof, so that a self sustained ecosystem could be developed eventually. The period assigned to carry out such ambitious project in **3 years** is not sufficient enough to make a full assessment of the success of the ecological restoration. At least a period of five **years** is essentially required to assess and evaluate the applicability and compatibility of ecological restoration in mined out areas. A fully restored ecosystem should have the following attributes: (i) similar diversity and community structure in comparison with reference sites, (ii) presence of indigenous species, (iii) presence of functional groups necessary for long-term stability, (iv) capacity of the physical environment to sustain reproducing populations, (v) normal functioning, (vi) integration with the landscape, (vii) elimination or reduction of potential threats, (viii) resilience to natural disturbances, and (ix) self-sustaining.

Therefore, keeping these in mind we propose to have a two years time for enhancing biodiversity and making area sustainable.

## FUTURE PLAN OF WORK

A project like ecological restoration which could be used as a model for any future projects of restoration by Coal India limited, require a thorough and precise study, evaluation and monitoring so that the Model plantation project may really turn out to a Model for other such future initiatives. The project needs sufficient period to develop into a fully compatible and sustainable project. A minimum period of **five years** (including 3 years earlier project period) would be enough for carrying out all the necessary assessments. Therefore, the following works would be carried out in the next two years.

### 1. Eradication of weeds.

The problem of weed infestation on the project site has been our primary concern. The weeds have been eradicated whenever required but its reoccurrence and highly invasiveness have hampered the proper growth of the plants planted in the project site. Weeds generally share similar adaptations that provide them advantages and allow them to proliferate in the project site. Weeds interfere by competing with the native plants species for the resources that a plant typically needs, namely, direct sunlight, soil nutrients, water, and (to a lesser extent) space for growth; providing hosts and vectors for plant pathogens, giving them greater opportunity to infect and degrade the quality of the native plants; providing food or shelter for animal pests such as seed-eating birds and Tephritid fruit flies that otherwise could hardly survive seasonal shortages. Therefore, the timely and periodical eradication of weeds is very necessary in such projects where plants have to be established well. The eradication of weed is very much time consuming and requires huge labour costs, however, in five years from now, the site could be completely free of weed infestation and plants planted would grow as to our expectations.

## 2. Gap filling

Some plants in the project may not survive in the harsh and adverse conditions of the project area and may die. In such case, gap filling becomes imperative, where dead plants are replaced by new plants. More seeds have to be broadcasted on those areas where the germination failed to occur.

## 3. Slope stabilization

Though lots of activities were carried out to stabilize the slope during three years of project period, still the slopes are on the process of disintegration. Mulching of the slopes was widely done in order to accelerate the natural process of disintegration and substratum build-up. The slopes which showed some positive results were effectively used for planting in the subsequent year of the project. While other slopes were again mulched so that it could be used for planting in the coming years.

## 4. Monitoring for growth and survival/protection

Monitoring for growth and survival of plants of ecological restoration project becomes an integral part of the project. Monitoring increases our understanding about ecosystem function and response thresholds and provides insights about which practices are effective. Monitoring feedback is used to modify or refine restoration practices, and promote better restoration success over time. The plants in the project site would require continuous supervision and monitoring for couple of years more. In addition to this, the protection of the project site from any biotic interference is necessary until the plants get well established and achieve its proper growth and development.

## ECOLOGICAL RESTORATION BY PROF. CR BABU

A team consisting of Shri Rajiv Kumar Garg (Advisor, Department of Coal), Dr. T. Chandini (Director, MoEF) and Professor C.R. Babu (Member of EAC for Thermal Power Plants and Coal Mines) visited Dhanbad from 6th – 8th July 2011. The objectives of the visit were to assess the status of OBDs and voids in coal fields of BCCL, to appraise the officers of the BCCL, ECL and CMPDI on the role of restoration ecology in vegetating OBDs to natural state of forest ecosystems characteristic to the area, restoration of voids to biologically productive ecosystems and to work out modalities for setting up model restored OBDs having native forest ecosystem using restoration ecology (The visit Report of Prof.CR Babu is annexed as Annexure-4)

BCCL has also taken up ecological restoration work on two over burden dumps of about 7 ha. at Damuda through the technical guidance of Prof. CR Babu, Vice-Chairman, Expert Appraisal Committee, MoEF-cum-Prof. Emeritus, Centre for Environmental Management of Degraded Ecosystems, School of Environmental Studies, University of Delhi. BCCL is involving the local people for the ecological restoration work over these two dumps. Bamboo plantation mixed with native species and ground cover with grasses has been done on the dumps. The total project is for 5 years and at the end of 5 years, the dumps are expected to have a native forest eco-system that provide ecological services, a grassland eco-system that provides fodder and mixed woodland eco-system that having mostly species that provides ecological goods besides eco-system services. In a similar manner, more mined out areas are being identified by BCCL for taking up ecological restoration work in these mined out areas.

## THE WAY FORWARD:

### STRATEGY FOR ECOLOGICAL RESTORATION

- Now under the back drop of the MoEF's stipulation for 'go no-go zones' for coal mining in the forest areas, BCCL has come up with the novel idea of converting the degraded and mined out land into no-go areas through ecological restoration thereby creating an asset of 'no- go' areas and thus guaranteeing 'Energy security' to the country. The ecologically restored areas would finally turn into dense forest areas that will support food chains and with the full bio-diversity. This endeavor by BCCL will set an example to other mining companies for creating no-go areas and thereby taking over of no-go areas for mining purpose from the government.

- The creation of no-go areas through ecological restoration shall involve Project Affected People which will provide livelihood opportunities and also the original forest habitats to the indigenous people/ tribes. This model will also help in restoring the pristine environment which was present during the pre-mining stage. Further this model will also reduce the ill-effects of pollution caused to the climate change; formation of carbon sinks thereby reduction of Green House Gases, improving the air quality and aesthetics and can also become a resource pool for timber harvesting and other forest produce to the surrounding society and the indigenous people. The

mining companies by this model will be in a position to create no-go areas and hand over the same to the society.

- This will be a society based work for also creation of awareness regarding organic farming, tusser farming, lac development, mushroom culture and other eco-friendly ventures. These NGOs, through their network shall help BCCL, as a media, to work for different CSR works like disposal of multipurpose surplus water scheme for irrigation and other purposes between BCCL and State Govt., between BCCL and local villagers/PAPs and between different Self Help Groups and Banking Institutions for creation of livelihood among PAPs. This exercise by the NGOs will create a model to the society and can facilitate the mining company for connecting with people as because after mining of the coal, the land is of no use and a liability to BCCL, and further under the Coal Bearing Act there is no provision to give back the mined out land to the State Govt. The mined out land can therefore be handed over to the Nodal agencies identified by FRI or the Delhi University's School of Environmental Studies, Centre for Environmental Management of Degraded Ecosystems (CEMDE) under the leadership of Prof. C.R. Babu for ecological restoration work.

**END RESULT OF ECOLOGICAL RESTORATION**

Ecological restoration will help in the overall upgrading of environment as well as improving the standard of living and economy of PAPs and the society at large. This effort shall also speed up the process of rehabilitation under the Jharia Master Plan, prompting voluntary shifting by the affected families. Even illegal coal mining and coal theft that is presently being practised by some sections of the society can be totally controlled. This shall be a role model and a win-win situation both for the mining company and the people of the Jharia coalfield. Through this model we can recreate wealth in the society.

The creation of NO-GO areas through ecological restoration shall involve Project Affected People which will provide livelihood opportunities and also the original forest habitats to the indigenous people/ tribals. This model will also help in restoring the pristine environment which was present during the pre-mining stage. Further this model will also reduce the ill-effects of pollution caused to the climate change; formation of carbon sinks thereby reduction of Green House Gases, improving the air

quality and aesthetics and can also become a resource pool for timber harvesting and other forest produce to the surrounding society and the indigenous people. The mining companies by this model will be in a position to create no-go areas and hand over the same to the society. This will be a society based work for creation of awareness regarding organic farming, tassar farming, lac development, mushroom culture and other eco-friendly ventures.

## APPRECIATION OF THE MODEL RESTORATION AT TETULMARI, DHANBAD

This innovative endeavor in the whole of coal mining industry, or rather in the whole of mining industry taken up by BCCL is being visited and widely appreciated by the regulatory authorities like the Expert Appraisal Committee of MoEF, MoEF itself, Chairman, CIL; D(P), Singareni Coal Company; Prof. S. P. Banerjee, Former Director, ISM; Prof. K. Mukherjee, ISM, State Pollution Control Board and various other dignitaries, academicians and experts.

## FUTURE PLANS OF BCCL FOR ECOLOGICAL RESTORATION

Seeing the success of the model plantation at Tetulmari, Sijua Area developed by FRI, Dehradun and ecological restoration at Damoda under the expert guidance of Prof. CR Babu, BCCL has started ecological restoration on 10.0 ha of land in 2013-14 and 44.03 Ha in 2014-15 departmentally. The results at these sites are as expected and encouraging. BCCL has aimed at doing ecological restoration as recommended in roadmap over 226.0 ha of degraded land and OB dumps. This project will continue for five years i.e., up to 2018-19.

BCCL has also signed a MoU with Forest Research Institute, Dehradun for seeking the technical advice/expertise for the ecological restoration works being undertaken by BCCL on OB dumps / mined out Areas on 44.0 Ha of degraded land in 2014-15. (A copy of MoU attached as annexure -5)

A proposal with regard to enhancement of Biodiversity and its conservation in the model plantation being developed by FRI, Dehradun (2011-14) at Tetulmari, Sijua Area has also been sent to BCCL, Dhanbad by Forest Research Institute, Dehradun. BCCL has confirmed that the proposal is in the advance stage of approval.

It has also been informed by BCCL that “Carbon Sequestration” study shall be instituted on the naked OB dumps, earlier plantation sites and the present Ecological restoration sites through a scientific agency to assess the amount of carbon sink formed.

**Acknowledgement** The authors would like to thank Bharat Coking Coal Limited (BCCL) for the financial assistance to carry out the project. We are also grateful to the Officers, Staffs and Management for providing facilities during the field visits.

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**i. Vasistha, H.B., Negi, M., Murmu, E. and Singh, L. (2013).** Growth performances of forestry and horticultural tree species on coal mine spoils in Dhanbad Coalfields, India**.** *e-Journal of Applied Forest Ecology*.

**ii**. **Vasistha, H.B., Negi, M., Murmu, E. and Singh, L. (2013).** An approach towards conserving biodiversity in Dhanbad coalfields of Jharkhand. *Proceeding Second National Biodiversity Congress*, West Bengal Biodiversity Board, Kolkata.

**iii. Vasistha, H.B., Negi, M., Murmu, E. and Singh, L. (2014).** Restoration of coal mined area of Dhanbad coalfield, Jharkhand- A need of the hour. Abstract. Tropical Ecology Congress, December 2014, Jawaharlal Nehru University (JNU).`

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**ANNEXURE-1**

IN THE HIGH COURT OF JHARKHAND
W.P (PIL) No. 3633 OF 2008

Gramin Ekta Manch Vs. State of Jharkhand & Ors.

CORAM HON'BLE THE CHIEF JUSTICE
HON'BLE MR.JUSTICE NARENDRA NATH TIWARI

For the Appellant/Petitioner Mr.P.K.Singh

For the Respondent-BCCL M/s. Gaurav Banerjee, Sr.Advocate, A.K.Mehta

13/19.1.2011 Today an affidavit has been filed giving some broad indications of what the respondent-company proposes to do. It is all abstract. We do not find any concrete thought having been germinated out of the process of so much persuasion by the Court and of course, of law including the stand of Ministry of Environment pressing to the coal mines. It is suggested that the Indian School of Mines has already been appointed as the Consultant to the Company to suggest the ways of forestation. This is one step. By itself, it may not be sufficient to satisfy the requirement of law, which makes it mandatory for the respondent-company to plant trees. The company may also consider to consult the Indian Institute of Forests, Dehradun, an Institute which has expertise in pursuing the cause of forest trees. May be late, some steps are being taken by the respondent-company. But with that we are not satisfied. Even being not satisfied we cannot force the respondent-company to raise the forest in a day, but we would like to see that the steps are taken in a right direction for which, to see the progress, we post this case after four weeks on 23.02.2011.

sd/- Bhagwati Prasad, C.J.
sd/- Narendra Nath Tiwari, J.

Certified to be true Copy

**ANNEXURE 2**

भारतीय गैर न्यायिक

एक सौ रुपये

Rs. 100

रु. 100

ONE HUNDRED RUPEES

भारत INDIA

INDIA NON JUDICIAL

उत्तराखण्ड UTTARAKHAND

E 339647

18 FEB 2011

## MEMORANDUM OF UNDERSTANDING

A Memorandum of Understanding entered into on the —— date of February, 2011 Forest Research Institute, Dehradun hereinafter referred to as FRI which shall include its representatives, successors and assignees of the one part.

**And**

Bharat Coking Coal Limited, Dhanbad referred to as BCCL (a subsidiary company of Coal India Limited, Kolkata), which shall include its representatives, successors and assignees of the other part.

**PREAMBLE**

Bharat Coking Coal Limited is desirous of availing technical expertise and capabilities of FRI, Dehradun by way of:

1. Procuring technical consultancy from FRI under the supervision of Head, Ecology and Environment Division, FRI, Dehradun to Bharat Coking Coal Limited, for preparation of the Road Map/ Action Plan for plantation work (in pursuing the cause of forest trees) in BCCL mine areas, based on scientific study.
2. Conducting a Rapid Ecological Appraisal of the mine sites of Bharat Coking Coal Limited, for the purpose of developing the Road Map/ Action Plan for plantation work, by FRI.

3. Documenting and producing a Technical report/ Road Map/ Action Plan for plantation work in BCCL mine areas by FRI and submission thereof to Bharat Coking Coal Limited. The report will be submitted in the month of April, 2011.

## 1. DURATION OF MoU

The MoU shall be affective from the date of signing and upto 30th April, 2011 for preparation of Road Map.

## 2. SCOPE OF WORK

FRI shall be responsible, by deputing their Scientists, project associates and other staff to achieve the successful preparation of the Road Map/ Action Plan for plantation works (in pursuing the cause of forest trees) in BCCL mine areas.

a) The Road map shall include soil working methods, soil and moisture conservation measures, choice of ecologically and socioeconomically viable plant species, methods of preparation of seed mix, methods of seeding and planting for ecological restoration of degraded mine areas.
b) NGO's / agencies who can successfully implement the Road map for ecological restoration /plantation work would be suggested in the Road map by FRI.

## 3. FINANCIAL TERMS

FRI's lump sum fees for providing Technical Services and preparation of the Road Map/ Action Plan for plantation work as per Article-2 above inclusive of taxes and duties, tours and other activities shall be Rs.19.50 lakhs (Rupees Nineteen lakhs and fifty thousand only) as detailed in Annexure-I.

The above fees shall be payable as follows:
50 percent along with work order and the balance 50 percent on successful completion of the work and submission of the report to BCCL.

BCCL shall provide all field logistics to FRI personnel like accommodation and conveyance facilities etc. during their field work/ visits to BCCL, Dhanbad.

## 4. FORCE MAEJURE

Neither party shall be responsible for non-fulfillment of their respective obligations under the MoU due to the exigency of one or more of the Force Majeure events, such as but not limited to act of God, war, flood, landslide, earthquake, cloudburst, riots, civil commotion etc. On the occurrence of such events, the parties shall jointly decide about the future course of actions and suitably extend the period of completion of assigned task.

**Annexure-I**

**Proposed Budget for developing the Road Map/ Action Plan for plantation work (in pursuing the cause of forest trees) in BCCL mine areas**

| Sl.No. | Proposed Expenditure | Budget (Rs.in lakhs) |
|---|---|---|
| 1. | All expenditure regarding consultancy, travel expenses, report preparation and other charges etc. | 13.68 |
| 2. | Institutional charges | 4.00 |
| | Service Tax @ 10.3% | 1.82 |
| | **Total** | **19.50** |

**Signatures**

**Forest Research Institute**
**Nominated Representative**

**Witness I**

**Witness II**

**Bharat Coking Coal Limited**
**Nominated Representative**

**Witness I**

**Witness II**

**ANNEXURE-3**

भारतीय गैर न्यायिक

एक सौ रुपये

Rs. 100

रु. 100

ONE HUNDRED RUPEES

सत्यमेव जयते

भारत INDIA

INDIA NON JUDICIAL

उत्तराखण्ड UTTARAKHAND

E 309637

- 7 JUL 2011

कोड सं. 001

CONTRACT AGREEMENT

THIS CONTRACT is made on this 28th day of July'2011 BETWEEN-THE FOREST RESEARCH INSTITUTE, A Central Government – Constituted Research Institute, P.O. : New Forest Dehradun, Uttarakhand hereinafter referred as F.R.I. which expression unless excluded by or repugnant to context shall mean and be included its successors, representative and assignees through its authorised nominated representative as named below with designation in F.R.I. of one part.

AND

M/S BHARAT COKING COAL LTD., a Central Government company and a subsidiary of COAL INDIA LIMITED having it's registered office KOYLA BHAWAN, P.O.: KOYLA NAGAR, police-station-SARAIDHELA, DIST: DHANBAD in the state of JHARKHAND hereinafter referred to B.C.C.L. (which expression unless repugnant to the context shall mean and be deemed to include its successors, authorised representative and assignees) through its authorised representative with designation as named below:-

PREAMBEL

WHEREAS B.C.C.L is desirous of availing technical expertise and capabilities of F.R.I. in the matter of below mentioned jobs:-

1. Procuring technical consultancy from FRI to Bharat Coking Coal Limited for developing ecological restoration model in mine spoils at Tetulmari under Sijua area (about 8-10 ha) of BCCL mine;

2. Seeking assistance of FRI scientists under supervision of Dr. H. B. Vasistha, Scientist-E, Ecology and Environment- Division, FRI Dehradun for execution in soil working, soil and moisture conservation measures, selection of plant species, preparation of seed mix, seeding and planting in mined out area

3. Conducting periodic ecological monitoring of treated mined area by FRI.

4. Documenting and producing annual ecological monitoring report by FRI and submission thereof to Bharat Coking Coal Limited, Dhanbad. The report will be submitted in the month of March every year.

AND

WHEREAS in course of negotiation and correspondences rested on the issue FRI agreed to provide B.C.C.L. technical expertise and capabilities.

NOW THIS AGREEMENT WITNESSETH AS FOLLOWS:-

DURATION OF CONTRACT

1. The contract shall commenced and be effective from the date of signing this agreement for a period of three years i.e. from July, 2011.....to.....June 2014.....with scope of renewal for further period agreed mutual terms between the parties hereto.

2. SCOPE OF WORK UNDER THE CONTRACT

FRI shall be solely and exclusively liable by deputing their scientists, Junior Research Scholar and other competent staffs in achieving the success of development of ecological restoration model in mine spoils at Tetulmari under Sijua area (8-10 Ha) in the mine of B.C.C.L. like:-

(i) FRI Scientist's/Staff under the supervision of Dr. H.B. Vasistha, Scientist-E, Ecology and Environment Division shall be responsible for execution of ecological restoration of mine spoils at Tetulmari under Sijua area of B.C.C.L Mines, Dhanbad.

-2-

(II) The work will include, soil working methods, soil and moisture conservation measures, selection of ecological and socio economic viable species, preparation of seed mix, seeding and planting in mined out areas.

(III) Periodic ecological monitoring and submitting annual report thereof to B.C.C.L.

3. FINANCIAL TERMS

FRI's lump sum fees for taking restoration as per Article-2

Above inclusive of taxes and duties, tours and other material cost shall be Rs. 20 Lakhs (Rupees Twenty Lakhs) only as detailed in Budget Estimate.

The above fees shall be payable as follows:-

50 percent in July, 2011

30 percent in July, 2012.

20 percent in July, 2013.

B.C.C.L. shall provide all field logistics to FRI personnel like accommodation, food and conveyance facilities etc. during their field work/visits to B.C.C.L. Dhanbad.

4. FORCE MAJEURE

Neither party shall be responsible for non fulfilment of their respective obligations under the Contract Agreement due to the exigency of one or more of the Force Majeure events, such as but not limited to act of God, war, flood, landslide, earthquake, cloud-burst, riots, civil commotion etc. on the occurrence of such event the parties shall jointly decide about the future course of actions and suitably extend the period of completion of assigned task.

5. Any controversy or dispute relating the contract agreement shall be resolved by mutual discussion.

6. If any dispute or difference arises between the parties hereto as to the construction, interpretation, effect and implication of any provision of this Agreement including the rights or liabilities or any claim or demand of any Party (or its extent) against other party or its sub-contractor or in regard to any matter under these presents but excluding any matters, decisions or determination of which is expressly provided for in this agreement and is not resolved by mutual discussions as referred in para-5, such disputes or differences shall be referred to the sole arbitration of the Director General, Indian Council of Forestry Research & Education (ICFRE), or his nominee.

BUDGET ESTIMATE

| SL. NO. | Budget Details | Budget (Rs. In lakhs) |
|---|---|---|
| 1. | All expenditure regarding consultancy stipend of junior research fellow, field assistant, travel expenses, material Cost, report preparation and other charges etc. | 16,13,000-00 |
| 2. | Institutional Charges | 2,00,000-00 |
| | Service Tax @ 10.3 % | 1,86,739-00 |
| | Total | 19,99,739-00<br>Say 20,00,000-00 |

Signature

Forest Research Institute

Nominated Representative

Witness - I

Witness - II

Bharat Coking Coal Limited

Nominated Representative

Witness - I

Witness - II

GENERAL MANAGER (E.N.V.)
B.C.C.L. Koyla Bhawan (H.Q.)

**ANNEXURE-4**

# Report on the Status of Overburden Dumps (OBDs) and Mine Voids of Coal Mines of BCCL (Dhanbad) and Ecological Restoration of OBDs

*Prof. CR Babu, CEMDE, Delhi University*

## The Visit

A team consisting of Shri Rajiv Kumar Garg (Advisor, Department of Coal), Dr. T. Chandini (Director, MoEF) and Professor C.R. Babu (Member of EAC for Thermal Power Plants and Coal Mines) visited Dhanbad from 6th – 8th July 2011. The objectives of the visit were to assess the status of OBDs and voids in coal fields of BCCL, to appraise the officers of the BCCL, ECL and CMPDIL on the role of restoration ecology in vegetating OBDs to natural state of forest ecosystems characteristic to the area, restoration of voids to biologically productive aquatic ecosystems and to work out modalities for setting up model restored OBDs having native forest ecosystem using restoration ecology.

On the evening of 6th July 2011, the team interacted with the officials of BCCL, ECL and CMPDIL consisting of Shri P.P. Gupta (General Manager, Environment, BCCL), Shri E.V.R. Raju (Senior Manager, Environment, BCCL), Shri B.K. Sharma (Chief Manager, Environment, ECL), Shri J.K. Goel (Chief General Manager, Environment, CMPDIL) and other officials, under the Chairmanship of Shri D.C. Jha (Director, Tech.-Operation, BCCL).

The officials of the Environment Division of BCCL explained the areas already vegetated by the State Forest Department and its status, the Court Directive to BCCL on the ecological restoration of all the OBDs in the BCCL coal field and their keenness to adopt restoration ecological technologies for vegetation development on OBDs. After brief introduction by Shri Jha, Professor Babu presented the different facets of restoration ecology and ecological principles underlying it and its advantages over rehabilitation and reclamation. The officials appreciated the restoration ecological approach for vegetation development on OBDs and were keen to adopt it.

On the forenoon of 7th July 2011, the team visited the restored Jhunkundar closed open cast mine located in Chanch-Victoria area of BCCL. There was a deep void of 26.71 ha containing 104 million gallons of water with a vegetated OBD on one side and a hillock on two sides of it. The water from the

void is supplied to surrounding villages and BCCL employees. The low lying area adjacent to the void was densely vegetated. The hillock was highly degraded.

On the way to freshly made inactive OBDs at Damuda colliery many OBDs, which were vegetated by the Forest Department, were also observed.

The inactive OBDs of 7 hectares located at Damuda colliery were assessed. The natural forest patches located close to OBDs of Damuda area were also examined.

In the evening of 7$^{th}$ July 2011, the team along with Shri D.C. Jha, Shri P.P. Gupta and Dr E.V.R. Raju met the Chairman cum Managing Director (CMD), Shri T.K. Lahiri. The CMD also showed keen interest in restoring the OBDs and voids of not only BCCL but also of all the coal fields using restoration ecology. He expressed his desire that the mined areas in coal fields should be transformed into native dense forests which can be subsequently can be designated as 'no go' area. He would be pleased to extend full support for ecological restoration of OBDs and voids. He has requested his Director, Shri Jha to work out the modalities to initiate work on the ecological restoration of OBDs in BCCL.

Professor Babu delivered a talk on the role of restoration ecology in developing vegetation cover on the OBDs having the ecosystem characteristics (structure, composition and function) similar to the original ecosystem of the area to about 50 General Managers of different mines in BCCL and ECL coal fields. The General Managers appreciated the ecological restoration approach and keen to adopt the restoration ecological practices in the mine reclamation.

On 8$^{th}$ July morning the team interacted with Shri S.Ghosh (Chief General Manager, Environment) and Shri B.K. Sharma (Chief Manager, Environment) of CCL and discussed the development of model plots to demonstrate the ecosystem redevelopment through development of vegetation cover using restoration ecology.

**Present status of OBDs and voids in coal fields of BCCL**

The OBDs cover several thousands of hectares. About 23 sq. km. area of OBDs have been revegetated in the past. Some of the revegetated OBDs were assessed. Most of the trees found on the OBDs are of exotic origin. Species such as *Acacia auriculiformis, Cassia siamea, Pongamia pinnata,*

*Peltophorum, Leucaena leucocephala, Pithecellobium dulce*, Neem, *Melia azedarach, Dalbergia sisso* and *Acacia nilotica* are found on the OBDs. In some vegetated mounds, trees on the top of the mound as well as in the upper slopes are dead and the lower slopes are slided. The middle slopes harbour some trees. Non-mineral bearing area around the OBDs are invaded by some of the top ten worst weeds and these include *Chromalaena, Parthenium, Hyptis suaveolens,* besides *Lantana, Croton bonplandianum* and other noxious weeds such as *Xanthium strumarium.* There is no grass over nor native trees on the OBDs. Some patches of *Dalbergia sissoo,* Neem and *Ficus* species are also observed on the OBDs.

In other words even exotic trees failed to establish on upper slopes and tops of 30 to 40 m OBDs and massive slips (landslides) are observed and these slips are invaded by invasive species.

Jhunkundar closed open cast mine located at Chancha-Victoria area is vast and spreads over an area of 26.71 ha and it stores 104 million gallons of water. It is surrounded by a hillock on one side, steep vegetated slope of OBD on one side and low lying area on the other side. The entire slope of OBD facing void is composed of *Chromalaena* except a few *Acacia auriculiformis* trees. The hillock is degraded and eroded with a few bamboo clumps and a part of it is grassed. The low lying area has dense tree cover.

The area around human settlements, road sides, railway tracks and open mineral bearing area are invaded by invasive weeds replacing native grasslands leading to extreme scarcity of fodder to the livestock. The native forests have also been degraded except in some patches where three storeyed forest exists. The water from the void is used to supply water to villages. A few birds such as Cormorants are spotted. The void may be very deep and may not be biologically productive, although local communities practice pisciculture. Phyto-and zooplankton appear to be scarce.

At Damuda colliery, there are two freshly made inactive OBDs. One spreads over an area of 2 hectares which is behind the active mine front and it is backfilled OBD to the ground level to a large extent but in some places it is about 10-20 m above the ground level. It forms contiguous zone with non coal bearing area where coal was dumped. The entire area of more than 5 to 8 hectares is barren except for *Hyptis* and *Chromalaena.* The OBD and its steep slopes are highly uneven, rugged with scattered boulders and stones (Image 5). There is a little soil which appears to be sandy layer of deep soil horizon. A few grasses such as *Eragrostis* are observed besides invasive weeds.

**OBD of Damuda Colliery to be ecologically restored to original natural forest ecosystem**

**Coal-bearing degraded landscape showing mine quarry**

The other OBD appears to be external dump which is about 30 to 40 m high with steep slope and covers an area of 5 hectares. This is also composed of boulders and stones. In between the two OBDs there are open barren areas which are probably ore bearing and covered with bushes, invasive weeds and some grasses; there is a void with water close to the dump.

**Status of forests located close to the OBDs on coal bearing and non coal bearing areas**

There is no tree cover on coal bearing areas and only have coppicing stems of *Butea,* bushes of *Lantana, Chromalaena, Hyptis* and other weeds . Grasses such as *Neyrudia, Bothriochloa, Eragrostis, Eleusine, Sporobolus* and *Chloris* were also observed. These areas are probably deforested for mining.

Close to the OBDs there is a native forest which is open mixed dry deciduous type with three storeys. It is extremely degraded due to intense grazing and felling of trees and no regeneration was observed. There are patches of three storeyed forests. The top layer is composed of *Adina cordifolia,* the

middle storey is composed of *Sterculia, Lagerstroemia parviflora, Holarrhena* and the third storey is composed of *Nyctanthus, Gardenia, Murraya* and others.

The ground flora is composed of mostly annuals. Invasive weeds such as *Chromalaena* and *Lantana* are common. *Hyptis suaveolens* is most abundant in open area. Bamboo clumps were also observed.

**Action Plan for ecological restoration of 7 hectares of OBDs and voids located close to OBDs**

The following steps would be followed in the restoration of OBDs:

(i) Field surveys and collection of native propagules of native grasses and legumes. Total 10-15 grasses and 5-10 legume species will be selected.

(ii) If the grass seeds are not adequate enough, the grass clumps will be uprooted and rootstock having 2 to 3 clumps will be separated and will be directly planted on the site. If seeds are available in large quantity, the seeds will be collected and mixed with cattle dung (fresh): soil mixture (2 parts of dung: 1 part of soil) and made into pellets and these pellets will be broadcasted. Hard seeds of legumes will be soaked in boiled water for one minute and these seeds will also be broadcasted.

(iii) Stocks of the grasses and legumes will be maintained in the nursery that will be developed. The nursery multiplied saplings will also be planted on the OBDs to enhance the density for moisture retention and prevention of soil erosion.

(iv) Collection of seeds and saplings from native forest species (top canopy, middle storey and underwood species) and their maintenance in the nursery till the grass cover is established on the OBDs. It will take 3 to 6 months to establish grass cover.

(v) Isolation of beneficial microbes from rhizospheric soils and roots of grasses and legumes and their enrichment in broth cultures. These cultures will be used as inoculants of consortia of microbes which will be added directly to the grasses already established. Encapsulated seeds with sodium alignate gel having immobilized consortium of microbes (nitrogen fixing, phosphate solubilizing and sidrophore producing bacteria) will be broadcasted. Soil inoculum with spores of AMF and root fragments infected with AMF will also be added to the saplings. These microbes enrich the nutrient status of the habitat and establish feedback loops that lead to establishment of nutrient cycling.

(vi) To stabilize the slopes, local bamboo species will be planted after the establishment of grass cover.

(vii) Saplings of light demanding species, particularly top canopy species, raised from seeds or from saplings collected from the forest and grown in the nursery will be introduced. If mycorrhizal inoculants are needed for these species, these will be introduced.

(viii) Soil invertebrates will be introduced after leaf litter is accumulated on the ground and litter decomposing Fungi will also be added.

(ix) A part of the vegetated OBD with grass will be developed into a mixed woodland community consisting of Bamboos, fruit yielding species such as Jackfruit (2 species of *Artocarpus*), *Madhuca, Diospyros, Annona, Grewia, Aegale* and *Moringa, Zizyphus,* Jamun, besides host plants of lac and tasar silk.

**At the end of 5 year, the OBDs will have: (i) a native forest ecosystem that provides ecological services, (ii) a grassland ecosystem that provides fodder and (iii) a mixed woodland ecosystem having mostly species that provide ecological goods besides ecosystem services. The OBDs requires protection from cattle grazing during their restoration. This can be done by stone piling.**

**Restoration of Voids**

The topography, depth of void and turbidity of water would be studied. Accordingly phyto-and zooplankton and submerged aquatic plants will be introduced. Fingerlings will be introduced after assessing primary productivity of water body.

**Mode of Implementation**

The Centre of Excellence Programme of MoEF at CEMDE (University of Delhi) will implement the programme with the Assistance from the Environment Division of BCCL. Professor C.R. Babu and one scientist from the Centre of Excellence Programme will be associated with the work to be carried out at BCCL.

**Native forest ecosystem at Damuda area**

**Native forest ecosystem at Damuda area showing three storied stratification of cover**

The BCCL may provide two undergraduate students from a local college who will be trained by us in the restoration ecology. These two trained assistants will help in setting up lab and nursery with our help and also mobilize local self help group of 6-8 people in maintaining the nursery and collection of seeds/saplings/clumps of native grasses and broadcasting of seeds, adding inoculants to soil and planting saplings.

We may need watering facility in the first two years during dry period. The expenditure on the two trained technical assistants and local self help group may be met from CSR Scheme of BCCL or from the scheme of OBD restoration. These 10 people will train all other persons who will be needed to carry out ecological restoration of all the OBDs of BCCL.

भारतीय गैर न्यायिक

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भारत INDIA

INDIA NON JUDICIAL

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## MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding is being entered into on ..... Date of June, 2014 between Forest Research Institute, Dehradun hereafter referred to as FRI which unless repugnant to the context shall include its representatives, successors and assignees on the one part.

**And**

Bharat Coking Coal Limited, Dhanbad hereafter referred to as BCCL (a subsidiary company of Coal India Limited, Kolkata), which unless repugnant to the context shall include its representatives successors and assignees on the other part.

**PREAMBLE**

As per the Hon'ble High Court of Jharkhand's directives for preparation of Road map through FRI, which was complied by BCCL and in the road map, monitoring mechanism for implementation of eco-restoration has been framed. It has been prescribed that FRI can extend short term and long term evaluation and monitoring of eco-restoration and that shall be taken up by BCCL. This Road map has also been filed in the Hon'ble High Court of Jharkhand. BCCL has also an MoU with FRI for developing model eco-restoration at Tetulmari Colliery of Sijua Area since 2011-12.

Subsequently, it has been decided by BCCL to take up the ecological restoration works on OB dumps / mined out areas starting from 2014-15 departmentally, using surplus manpower from different Areas.

D. C. Jha
DIRECTOR (TECH)OP
B.C.C.L. KOYLA BHAWAN

Subsequently, BCCL has started the preparatory works at the following OB dumps/ mined out areas.

| Sl. No. | Name of Area | Name of the Project/Site | Location | Area in Ha |
|---|---|---|---|---|
| 1. | Barora. | Phularitand | Adjacent of KKC – Link siding | 2.50 |
| 2. | Block-II. | Block-II. | Beside the Explosive Magazine | 3.60 |
| 3. | Gobindpur Area | New Akashkinari Colliery | New Akashkinari Colliery OB dump | 4.0 |
| 4. | Katras. | AKWMC OCP. | Near Explosive Magazine. | 3.40 |
| 5. | Kusunda. | Khas Kusunda | Gondudih | 2.00 |
| 6. | EJ (Bhowra & Sudamdih). | Bhowra(South) | OB dump of water pumping plant of Bhowra (south) 3 pit OCP | 8.73 |
| 7. | WJ Area | Murulidih Colliery | | 4.20 |
| 8. | Bastacolla Area | South Jharia/ R.O.C.P | above the Bank of Chatkari Jore | 10.00 |
| 9. | C.V Area | Abundant Junkundar OCP. | Embankment of Junkundar | 5.60 |
| | | | TOTAL=44.03 or say 44.0 HA | |

Following this, Director, FRI, Dehradun vide letter no. 39/4-74/D&P-14, dated 19.02.2014 has submitted a proposal for offering technical services, guidance, supervision, monitoring, documentation etc. For the ecological restoration that are being taken up by BCCL in the above mentioned sites at the cost of Rs.1.557 lakhs per hectare for five years exclusive of service tax which at present is @ 12.36%.

**1. Scope of Work**

FRI shall be solely and exclusively liable by deputing their scientists, senior/junior research scholar and other competent staffs in providing technical guidance to BCCL for achieving the success of developing ecological restoration works on OB dumps / mined out Areas of BCCL mines (*44.00* Ha at 9 different sites) being undertaken by BCCL like:

a) FRI scientists/ staffs under the supervision of Ecology & Environment Division, FRI, Dehradun shall be responsible for acting as technical advisor/ expert, guidance, supervision, monitoring of action plan/ activities, documentation (in report form, videography and photography), scientific assessment including various types of analyses, imparting training to BCCL personnel etc for the ecological restoration works on OB dumps/ mined out Areas of BCCL mines (*44.00* Ha) being undertaken by BCCL at different sites FRI shall depute JRF/SRF during the project period at BCCL, Dhanbad.

b) The JRF/SRF deputed by FRI at BCCL shall interact with the officials of BCCL on various activities of ecological restoration being done by BCCL at different sites.

c) The works will include advise reg. soil amelioration and management, silviculture, pathology, entomology, soil working, soil & moisture conservation measures , selection of plant species, seeds selection, assist in identifying authentic seed/ nursery vendors/ agencies, preparation of seed mix, seedling and planting in mined out areas.

d) The monitoring and scientific assessment including various types of analyses, carbon estimation etc and Documentation (in report form, videography and photography) will be carried out once in every 04 months along with monitoring report during project period of 05 years by FRI, Dehradun and submission thereof to Bharat Coking Coal Limited, Dhanbad.

e) BCCL has the right to alter, modify, delete any of the terms of this MoU and also add additional terms to this MoU with mutual consent of both the parties.

DIRECTOR (TECHNICAL) B.C.C.L. KOYLA BHAWAN

2. **Duration of MoU**

The MoU shall be effective from the date of signing and up to 5 years.

**A. JOBS REQUIRED TO BE DONE BY/ RESPONSIBILITIES OF FRI, DEHRADUN**

1. Providing technical guidance, services, guidance, supervision, monitoring of action plan/ activities, documentation and assessment etc for the ecological restoration from FRI, Dehradun to Bharat Coking Coal Limited for developing ecological restoration works on OB dumps/ mined out Areas of BCCL mines (*44.00* Ha at 9 different sites) being undertaken by BCCL.
2. Seeking assistance of Forest Ecology & Environment Division, FRI, Dehradun for the execution in soil amelioration and management, silviculture, pathology and entomology, soil working, soil & moisture Conservation measures , Selection of plant species, preparation of seed mix, seedling and planting in mined out areas.
3. The monitoring and scientific assessment including various types of analyses, carbon sequestration etc and Documentation (in report form, videography and photography) will be carried out once in every 04 months during project period (05 years) and producing monitoring report after every 04 months i.e. April, August and December during the project duration (05 years) by FRI, Dehradun and submission thereof to Bharat Coking Coal Limited, Dhanbad.
4. An annual interim report will be submitted by FRI, Dehradun in the month of October of every completed year.
5. Propagation of BCCL's ecological restoration work under FRI's technical guidance shall be done by FRI at various national & international forums, Conferences, Seminars, FRI's newsletters & annual reports.
6. FRI, Dehradun shall also impart two trainings with no additional cost with starting of the project:
   a) Once at FRI, Dehradun, the training will be organized in FRI, Dehradun, the no. of participants will be in between 15-20, their travelling cost from Dhanbad to Dehradun and back will be borne by BCCL where as other cost like Boarding, lodging and others will be borne by FRI, Dehradun, and
   b) Another training to be organized at Dhanbad, for that there will be no limitation of number of participants, only condition that their lodging, boarding and local travelling cost will be borne by BCCL.

**B. JOBS REQUIRED TO BE DONE BY/ RESPONSIBILITIES OF BCCL, DHANBAD**

- Officers/ Scientists / Staff who will visit to Dhanbad as a resource person for imparting training, their local arrangements i.e. their lodging, boarding and local transport will be borne by BCCL. Travelling cost of these resource persons from Dehradun to Dhanbad and back will borne by FRI itself.
- BCCL shall provide transportation to the JRF/SRF deputed by FRI stationed at BCCL, Dhanbad as and when transportation means are available. However, in the case of non-availability of transport means, Field personnel of FRI may make arrangement for local transport by his/her own.
- BCCL shall provide accommodation to the JRF/SRF deputed by FRI stationed at BCCL, Dhanbad.
- BCCL shall provide accommodation and transportation to the field personnel/officers of FRI during field visits to restoration sites.

1. **Financial Terms**

The cost of technical consultancy, services, guidance, supervision, monitoring of action plan/ activities, documentation & assessment and soil amelioration & management, silviculture, pathology, entomology, soil working, soil & moisture Conservation measures, Selection of plant species, preparation of seed mix, seedling and planting in mined out areas including two trainings is rupees 1.557 lakh per hectare for 05 years. This cost is excluding of service tax which at present is 12.36%.

The total cost of the project is *Rs. 76.97558 Lakh* (Rupees seventy six Lakh ninety seven thousand five hundred fifty eight only) for five years @ of Rs. 1.74944 lakh (Rupees one lakh seventy four thousand nine hundred forty four only) per hectare, inclusive of service tax.

Therefore, as per present practice of BCCL, FRI shall submit the bills @ of Rs. 1.74944 lakh (rupees one lakh seventy four thousand nine hundred forty four only) per hectare, inclusive of service tax.

The mode of payment shall be as follows:

a) 10% of total Project cost, after award of work order.
b) 25% of total Project cost, after submission of 1st interim report.
c) 25% of total Project cost, after submission of 2nd interim report.
d) 15% of total Project cost, after submission of 3rd interim report.
e) 15% of total Project cost, after submission of 4th interim report.
f) 10% of total Project cost, after submission of final report.

**2. Force Majeure**

Neither party shall be held responsible for non-fulfillment of their respective obligations under the MoU due to the exigency of one or more of the force majeure events, such as flood, war, landslide, earthquake, cloudburst, riots, epidemics, fire, civil commotion etc. provided on the occurrence of such events, the party affected hereby gives a notice of cessation in writing to other party within one month of such occurrence. If the force majeure continues for more than six months, the parties shall jointly decide about the future course of actions.

**3. Arbitration/Dispute Resolution**

If any dispute or difference arises between the parties hereto as to construction, interpretation, effect and implication of any provision of this MoU including the rights or in regard to any other matter under these presents but excluding any matters, decisions or determination of which is expressly provided for in MoU, such disputes or differences shall be referred to a committee consisting of Chairman cum Managing Director, BCCL or his nominee and Director of the Forest Research Institute, Dehradun, or his nominee. A reference to the Arbitration under this clause shall be deemed to be submitted within the meaning of the Arbitration & Conciliation Act, 1996 and the rules framed there under for the time being in force.

**Signatures:**

Forest Research Institute
nominated representative

Bharat Coking Coal Ltd
nominated representative

Witness 1: 6/6/14

Witness 1: 6/6/14

Witness 2:

Witness 2: 6/6/14