RESTORATION OF MINING AFFECTED AREAS IN CUMARCONDA
FOREST LANDSCAPE, GOA, INDIA

by

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A Forest Landscape Restoration Snapshot Report
prepared by the

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ACRONYMS

ERW- Electrical Resistance Welding
EMP- Environmental Management Plan
FLR- Forest Land Reclamation
GDP- Gross Domestic Product
GSPCB- Goa State Pollution Control Board
IUCN- International Union for Conservation of Nature
IBM- Indian Bureau of Mines
ICAR- Indian Council of Agriculture Research
NGO – Non Government Organisation
NDC - Nationally Determined Contribution
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RESTORATION OF MINING AFFECTED AREAS IN CUMARCONDA FOREST LANDSCAPE, GOA, INDIA

Deep Shikha Sharma, Subhash Chandra, Promode Kant

EXECUTIVE SUMMARY

Mining for iron ore is an important sector of the economy of Goa contributing almost one fifth of the Gross State Domestic Product of the state. Almost all mining is open cast involving deforestation, removal of the topsoil and creation of huge mining pits and overburden dumps. The remediation of mines after completion of mining is an important part of approved mining plans and the mining companies are required by law to rehabilitate the mining sites as per Mine Closure Plans that are an integral part of the permission to mine.

The mining affected forest landscape under study is the Cumarconda Forest Beat in Valpoi Range, North Goa Forest Division covering an area of 2,835 ha. Changes in land use pattern of this landscape were examined for the period 2005 to 2018. A comparative analysis was carried out by observing land use changes over the selected landscape over the years (2005, 2007, 2013, 2015 and 2018) while the mine reclamation study focussed on changes in a small part of the landscape called the Pissurlem mine dump site. The area under mining and dumping in the landscape increased from year 2005 to 2007 due to the so-called China Boom and then decreased sharply from 2013 onwards as environmental concerns mounted leading to interventions by both the Bombay High Court and the Supreme Court of India. Most mining took place in open or degraded forests leading to a decrease in the Open Forests category within the landscape while there was almost no change in the area under Medium Density Forests and Very Dense Forests as also in the area under habitation, cultivation and other uses.

The Pissurlem dump first appears in the year 2007 in the Google Earth images which shows continuous increase in the dump area till 2013 consistent with the increase in area under mining. The mining company responsible for creation as well as reclamation of Pissurlem mine dump, prepared an Environmental Management Plan for the mine dumpsite of which this reclamation was a part and, after approval by Environment Department of the Government of Goa, the same was implemented in the field. An important fact to note is that even though reclamation is mandatory under the law the mining company, as was the general practice by all mining companies, gave very low
priority to reclamation activities till the Courts intervened with exemplary punishments to the defaulters.

Preparations for reclamation began with de-silting of settling ponds and excavation of new settling ponds to store water, smoothening of terrace slopes, compaction of terrace surfaces with heavy duty bulldozers, excavation of garland drains around the dump as also drainages on the terrace by stone pitching and placement of ERW (Electrical Resistance Welding) pipes and laying of protective cover of geo-textiles or jute-mats on the terrace surface before the onset of monsoon. With the beginning of monsoon grass seeds were spread on the protective cover to prevent surface erosion and *Glyricidia sepium* was planted as pegs for further stabilizing it. In the following month plantation of desired saplings was undertaken with labour contracts awarded through the community. Species planted include cashew as desired by local communities as well as leguminous species such as *Acacia auriculiformis* and *Acacia mangium*. Acacia species were preferred because these do not require aftercare and grow faster, and also because these add to the soil fertility through nitrogen fixation. *Acacia auriculiformis* plantations at 7 years have an average height of 11.21m with a thick canopy resembling natural forest of the region and attracts birds and other animals such as leopard, hares, porcupines etc. This stands in sharp contrast with neighbouring dump sites that have remained untreated where the regrowth vegetation is scanty at best. Some patches, where Cashew was planted in deference to local demand, also show slower growth having average height of 6.61m at the same age. Also, the density is much lower both on account of lesser number of cashew plants planted per ha and also because cashew does not encourage undergrowth of other species. Relatively quick restoration of mining and dumping sites was possible through the application of well-designed methodologies that can be developed for each site by trained professionals. Fast growing grasses, shrubs and trees, both indigenous and exotic, brought the mining and dump sites under vegetative cover within a short time keeping soil particles intact thereby preventing erosion and stabilizing the site.

The central problem in rehabilitation of mined land is not technical difficulties but the low priority often accorded to the task by the mining companies responsible for it. Since direct interventions by higher courts to enforce the conditions of mining regarding rehabilitation everywhere is neither desirable nor possible it is important to create duly empowered mechanisms with adequate public participation in all mining sites to monitor progress and take preventive, corrective and punitive measures as appropriate.
1. INTRODUCTION

1.1 Forest landscape restoration is a long-term process of reclaiming ecological functionality and enhancing human well-being in deforested or degraded landscapes. Mining of minerals is a major extractive industry which forms an important economic activity providing essential raw materials for meeting the developmental needs of a country. The open cast mining of bulk minerals like iron, coal, bauxite and limestone among others, when done unsustainably, irreversibly alters the landscapes leading to adverse environmental and ecological consequences. However, responsible and scientific mining can bring significant benefits to state and its economy and also generate surpluses that can be used to invest in activities that support our environment and ecology positively.

1.2 Mining is an important sector of the economy of Goa, a mineral rich state on the western coast of India, where forests overlay mineral deposits. Goa has both hematite and magnetite iron ore, hematite being the major resource. National Mineral Inventory estimates place state’s hematite and magnetite reserves at around 1189.313 and 266.336 million tonnes (mt) respectively. The state contributes to 70% of all iron ore exports from India and in the year 2010-11 the contribution of mining sector to state’s GDP was as high as 20% employing over 60,000 persons directly and another 90,000 persons indirectly. This has, however, now come down significantly as related environmental degradation led to public protests.

1.3 Conversion of forest and other lands for mining purpose has become a matter of intense public debate in recent years and the mining activity is under strict scrutiny of various stakeholders. There are elaborate policy and legal framework governing mining sector viz. the Mines and Minerals (Development and Regulation) Act 1957; the Forest (Conservation) Act, 1980; the Environmental (Protection) Act, 1986; the Mineral Concession Rules, 2016; the Mineral Conservation and Development Rules, 2017 and National Mineral Policy, 2019 to name a few important ones besides directions issued by higher courts from time to time to regulate the industry.

1.4 The open cast mining for iron ore in the state involves deforestation, removal of the topsoil and extraction of ore creating huge mining pits and overburden dumps. The
unrestored mines lead to considerable environmental and ecological risks including pollution of air, water and soil and resultant loss of livelihoods and biodiversity and thus require scientific remediation. The remediation of mines after completion of mining is an important part of approved mining plans and mining agencies are bound to rehabilitate the mining sites as per Mine Closure Plan. The restoration involves backfilling of pits with top soil, afforestation, water and soil conservation measures etc. The deep pits created during mines are also source of water for irrigation and other purposes during dry season. Inadequacy in remediation of mined out areas in some cases, has caused severe criticism including from the judiciary. This paper reflects the outcome of the study of the area of a successfully rehabilitated mining dumpsite from the perspective of forest department to share the learning on good practices with other stakeholders.

1.5 **Boundaries of landscape restored:** The mining affected forest landscape under the study is a mine waste dump at Pissurlem area of Cumarconda Forest Beat in Valpoi Range, North Goa Forest Division in the North District. The landscape has an area of 2,835 ha and bounded on the north by Bhuipal beat, east by Zorme and Cudcem beat, south by Bhirondem and west by Surla beat, falling between 15° 32' 54.74" N and 15° 29' 52.90" N latitudes, and 74° 05' 14.38" E and 74° 02' 11.22" E longitudes. The area forms part of Survey of India Toposheet Nos. 48 E/10. A map of the landscape is illustrated below:

![Image](https://example.com/image1)

**Fig 1:** Landscape map of Cumarconda Forest Beat, Valpoi Range, North Goa Division showing different land use patterns

1.6 The landscape under study covers both forest & non-forest lands including lands under habitation, agriculture, horticulture, roads & mining as shown in Table 1 below:
Table 1: Table showing land used category in Cumarconda Beat in year 2005.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Beat</th>
<th>Land use Category</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cumarconda</td>
<td>Mine and dumping site</td>
<td>583.045</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Reclaimed mines</td>
<td>49.444</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Habitation, Agriculture &amp; Horticulture</td>
<td>586.538</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Medium dense forest/very dense forest</td>
<td>344.979</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Degraded land/Open forest</td>
<td>1270.54</td>
</tr>
<tr>
<td></td>
<td>Total Area (ha)</td>
<td></td>
<td>2834.55</td>
</tr>
</tbody>
</table>

2. LAND COVER/USE AND LAND COVER/USE CHANGE

2.1 The landscape has been affected by iron ore mining since the Portuguese colonial rule. However, study has been done since the year 2005 in view of availability of data. Out of total area of 2,835 ha, roughly 583 ha was being exploited for mining and dumping and 586 ha was under habitation, agriculture and especially horticultural plantations of cashew, areca nut, coconut, pineapple and black pepper. The area under medium dense to very dense forest vegetation is about 344 ha with forest vegetation of Tropical moist mixed deciduous forest type comprising primarily of *Terminalia crenulata*, *Terminalia chebula*, *Adina cordifolia*, *Alstonia scholaris*, *Lannea coromandelica*, *Bombax ceiba*, *Careya arborea* and *Dillenia pentagyna* etc. The remaining land (1,270 ha) was either open forest having canopy density ranging from 10-40%, scrub land having canopy density of less than 10%, or exposed laterite rocks which could not sustain vegetation.

2.2 The site has diverse terrain consisting of hills and valleys with variations in altitude, aspect and gradient. The altitude ranges from 3 meters to about 100 meters above MSL with minimum and maximum average temperature ranging from 20°C to 33 °C and with high humidity owing to closeness to the sea. Annual rainfall varies from 3000 mm to 5000 mm and the average number of rainy days is 110, which provides congenial conditions for regeneration and fast growth.

2.3 Major anthropogenic disturbance to the ecology of the landscape is from open cast mining, which is a temporary change in the land use. Iron ore is buried under layers of ordinary soil or rock (called ‘overburden’) which needs excavation mechanically to allow access to the metallic ore deposit. Due to excavations for mining and allied activities soil sequences get disturbed. Loosening of the natural compactness of ground results in soil erosion especially in hilly terrain during rains. The soil quality of the surrounding area also gets affected due to siltation and run off from waste.
dumps. In mines where working is done below the water table, pumping of water from the mining pit leads to pollution of water in the downstream and lowering of water table. Mud flows due to surface erosion during rains and pollutes water bodies in the catchment areas. The so-called China boom between 2006-07 to 2011-12 created high demand for the lower quality ore as well and led to increase in mining and dumping activity in the state including the project area.

3. DESIRED FUTURE LANDSCAPE: VISION FOR THE LANDSCAPE

3.1 The desired future landscape includes clean water bodies at the base with stabilised, afforested slopes, regaining of biodiversity, pollution checked, sustainable and diversified economic activities and infrastructure for supporting livelihoods and use of various stakeholders. The mining lease area in Sanquelim in North District of Goa spread over an area of 203 ha was successfully reclaimed in the preceding decades and can be taken as a reclamation model to follow. This mine was operational since 1956-57 and the reclamation work that began in 1980s mainly comprised of activities described in the following paragraphs.

3.2 Soil backfilling and stabilization: After the mineral exploitation activity was completed, the area was back filled with the overburden and top soil that was stacked in the vicinity at the starting of mining activity. The mine pits were back filled systematically by forming benches making it feasible to carry out plantation. During monsoon, small pits were excavated for planting the saplings of fast growing hardy tree species like *Acacia auriculiformis*, *Eucalyptus* hybrid and *Casurina equisetifolia*. Leguminous cover crop of Plureria, raised by direct seed sowing under the Acacia plantations, grew luxuriantly and over time replaced Acacia plantations naturally, thus making the stabilised land available for raising plantations of native species.

3.3 Economically and ecologically desirable planting: Several organizations in Goa, including the state forest and agriculture departments, the Rubber and Spice Boards, and the Goa University, have developed a range of model plantations for raising on the reclaimed and stabilized slopes with economically important crops including mango, banana, sapota, guava, lemon, pineapple, cashew, spices like black pepper, cinnamon, and medicinal plants etc. Many of these plantation crops were raised in different parts of the Sanquelim reclamation area with satisfactory results. An assessment of biodiversity enrichment suggests the presence of 3 species of mammals, 70 species of birds, 42 species of butterflies, 14 species of odonates, 12 species of reptiles and 10 species of amphibians in the reclaimed mine area.
3.4 Mining pits as valuable water bodies: Most mining pits were retained and converted to water bodies for rain water harvesting and used both for agriculture as also for raising fishes like rohu, katla and common carp as livelihood support. These water bodies also receive seasonal floods from neighbouring river which has led to the entry of crocodiles and otters in these water bodies besides attracting many species of water birds. Recreational activities such as boating have also been introduced attracting numerous visitors.

3.5 Utilisation of existing building infrastructure: The old infrastructure developed for mining operations such as buildings and workshops were converted into a technical school imparting vocational training and skilling for local youth and residential quarters were converted into a football academy for the local youth.
1 INTRODUCTION

1.1 BACKGROUND: Mining activity in India is regulated by Mines and Minerals (Development and Regulation) Act, 1957 and the rules made thereunder that are reflected in mining lease agreements as also the forest and environmental clearances issued under the relevant provisions of the Forest (Conservation) Act, 1980, and the Environmental (Protection) Act, 1986. Mining operations are allowed only after the approval of the mining plan for each mining site by the Indian Bureau of Mines and the Environmental Management Plan (EMP) approved by the State Environment Department.

1.2 The Directorate of Mines in the State is responsible for granting of mining leases and regulates mining activities. The Directorate General of Mines Safety under the Ministry of Labour and Employment, Government of India, carries out periodic inspection to ensure safety, risks mitigation and health of mine workers. Mining companies are required to submit periodic returns to all concerned regulatory agencies.

1.3 Mining is a commercial activity which is affected by cycle of economic growth based on global demand. There was significant increase in demand of iron ore around 2006-07, during the so called “China Boom” leading to more forest lands being brought under mining activity.

1.4 BRIEF ON FLR INITIATIVE:

Landscape restoration work has been carried out in many mining and dumping sites in Goa over the past three decades of which the Pissurlem dumping site under study is one. As was the practice till the Courts stopped it in 2012 the Pissurlem dump site was located in forest lands outside the actual mining lease area where the Vedanta Group of Companies used to dump reject material from several of their mines in the neighbourhood.

1.5 PROJECT DESCRIPTION AREA: The total geographical area of the Cumaronda forest landscape is 2,835 ha covering the entire extent of the forest beat by the same name. Out of the total area, area under different land uses in the year 2005 was as follows

i. Mining and dumping - 583 ha
ii. Reclaimed mines - 49 ha
iii. Habitation, agriculture and horticultural plantations - 586 ha
iv. Medium dense to very dense forest vegetation - 344 ha
v. Lands under Open forest category - 1,270 ha

1.6 The Table 2 below presents the changes in these land-use categories between 2005 to 2018. Area under reclaimed mines remained unchanged at 49 ha from 2005 to 2007 before increasing to 221 ha in 2013, 388 ha in 2015 and 417 ha in 2018 as Courts heavily penalized the recalcitrant mining companies for their failure to comply with the provisions of the Environment management Plans. During the same period the area under open forest decreased from 1,270 ha in the year 2005 to 1,157 ha in the year 2018 even though the area in medium dense forest and very dense forest categories remained almost the same. This is because the mining companies were able to access more degraded forest lands for mining activities and in just two years between 2005 to 2007 the land under mining and dumps jumped to 679 ha from 583 ha.

1.7 In November 2010 the Government of India constituted Justice Shah Commission to inquire into the widespread illegal mining activity across the country. Based on its two interim reports and the final report submitted in 2013, several interventions of Bombay High Court and the Supreme Court based on these reports, and consequential strict enforcement of mining regulations in view of growing environmental concerns, the total area under mining decreased to 556 ha by the year 2013.

![Change in Landuse Pattern with Time](image)

Fig 8 : Figure showing change in area under different landscape with time.
<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Beat</th>
<th>Category</th>
<th>Area in Base Year 2005 (ha)</th>
<th>Area in Year 2007(ha)</th>
<th>Change in Area (ha)</th>
<th>Area in Year 2013(ha)</th>
<th>Change in Area (ha)</th>
<th>Area in Year 2015(ha)</th>
<th>Change in Area (ha)</th>
<th>Area in Year 2018(ha)</th>
<th>Change in Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Mine &amp; Dumping Site</td>
<td>583.045</td>
<td>679.171</td>
<td>96.14</td>
<td>556.34</td>
<td>-122.83</td>
<td>388.74</td>
<td>-167.60</td>
<td>361.23</td>
<td>-27.51</td>
</tr>
<tr>
<td>2</td>
<td>Cumarconda</td>
<td>Reclaimed Mines</td>
<td>49.444</td>
<td>49.444</td>
<td>0</td>
<td>221</td>
<td>171.556</td>
<td>388.6</td>
<td>167.60</td>
<td>417.99</td>
<td>29.39</td>
</tr>
<tr>
<td>3</td>
<td>Cumarconda</td>
<td>Habitation, Agriculture &amp; Horticulture</td>
<td>586.538</td>
<td>579.218</td>
<td>-7.32</td>
<td>563.338</td>
<td>-15.88</td>
<td>563.338</td>
<td>0.00</td>
<td>563.338</td>
<td>0.00</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Medium dense forest/ very dense Forest</td>
<td>344.979</td>
<td>342.689</td>
<td>-2.29</td>
<td>334.869</td>
<td>-7.82</td>
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<tr>
<td>5</td>
<td></td>
<td>Degraded land/Open Forest</td>
<td>1270.54</td>
<td>1184.02</td>
<td>-86.52</td>
<td>1158.996</td>
<td>-25.027</td>
<td>1159</td>
<td>0.00</td>
<td>1157.12</td>
<td>-1.88</td>
</tr>
</tbody>
</table>

|       | Total |               | 2834.55 | 2834.55 | 2834.55 | 2834.55 | 2834.55 | 2834.55 | 2834.55 | 2834.55 | 2834.55 |

Table 2: Table showing change in area under different land-use over time.
1.8 OBJECTIVES:

The objectives of this study are:

a. To enhance scientific knowledge on restoration efforts in mining and dumping sites in the Cumarconda forest landscape.

b. To evaluate evidence on progress made in the restoration efforts.

c. To publish findings for policy learning and technical training of professionals.

d. To disseminate the findings across the global community faced with the problem of mining related forest degradation.

1.9 METHODOLOGY:

1.9.1 Methodology adopted to achieve the objectives: Field visits to reclaimed mine areas located at different locations were carried out with project leader and the staff of the concerned mining company. Already reclaimed Sanquelim mining and dumping site located in North Goa District covering an area of 203 ha was also visited along with Pissurlem mine dump site under study. After selection of project boundaries, the area was overlaid on Google Earth image year 2005 (base year for study) and different land use patterns were analysed on Google Earth. A comparative analysis was carried out by observing land use change over the years (2007, 2013, 2015 and 2018).
Fig 10: Figure showing land use pattern of Cumarconda Beat in year 2007.

Fig 11: Figure showing land use pattern of Cumarconda Beat in year 2013.
Fig 12: Figure showing land use pattern of Cumarconda Beat in year 2015.

Fig 13: Figure showing land use pattern of Cumarconda Beat in year 2018.
As evident from the Google Earth images, the area under mining increased from year 2005 to 2007 while it decreased from year 2013 onwards as the Courts took notice of the environmental damages and intervened sharply following Shah Commission’s interim and final reports. Area under reclaimed mine sites, shows more spread in year 2013 than in 2005. The increase in area under reclamation and decrease in area under mining can further be seen in images of year 2015 and 2018. Figure 10 shows the Google Earth image of year 2007 wherein degradation in the Pissurlem dump area can be seen for the first time relative to the site condition before dumping began (Figure 14). Figure 11 shows increase in dump area in year 2013. The Google Earth image of year 2018 (Figure 13) suggests shift to other occupations like agriculture, horticulture and lateritic stone quarrying.

Fig 14: Figure showing Pissurlem site before dumping.

Fig 15: Figure showing Pissurlem dump site in Cumaronda Beat.
Figure 16: Figure showing contour map of old reclaimed dump and new Pissurlem dump.

Figure 16 shows the contour map of old reclaimed dump and new dump under study. Detailed information about dump stabilization was obtained from various stakeholders like the mine company employees, village headmen, local villagers, school teacher, truck drivers, NGO members and officials from Indian Bureau of Mines through questionnaire forms and the inputs were used for analysing reclamation processes.

1.11 Stakeholders and their responsibilities: The various stakeholders of the Pissurlem mine dumping site reclamation were the mining company, forest and environment departments of the state government, department of Geology and Mines, Goa State Pollution Control Board, local people, and the NGOs. Local people were the end users of the reclaimed site and their responsibility was to give true feedback of the reclamation works while the NGOs acted as watchdogs of the reclamations work and also involved in educating and making the local people aware of the impacts of mining to their lives and livelihood.

1.12 Link to Bonn Challenge: Bringing back degraded and deforested lands is critical for mitigating climate change and building resilience to it. Bonn Challenge, a global initiative in support of climate change mitigation and adaptation through the forest sector, seeks to restore 150 million hectares of deforested and degraded land by 2020 and 350 million hectares by 2030. India has committed itself to restoring 26 million ha of degraded forest by 2030. In this backdrop, reclamations efforts in Pissurlem mining dump site are small but important steps in the right direction.
2. IMPLEMENTATION:

2.1 Responsibility for implementation:
The concerned mining company was responsible for the reclamation of Pissurlem mine dump carried out in accordance with the Environmental Management Plan (EMP) prepared by a multidisciplinary technical team involving the mine manager, geologist, surveyor and their environment team, and approved by the Environment Department of the Government of Goa.

2.2 Technical design of restoration interventions:
A topographical survey of the site was conducted as a preparatory measure to locate the drainage system including the garland drains, settling ponds, filter beds, terraces, roads and the construction of protective walls. Detailed technical designs of all these interventions were prepared by site engineers and the environment team of the mining company and implementation carried out under the supervision of the site manager.

![Fig 17: Figure shows ERW pipes for drainage.](image)

![Fig 18: Figure shows Garland drain on Terrace.](image)

![Fig 19: Figure shows lateritic Retention Wall on the foot of dump.](image)

![Fig 20: Figure shows settling pond at the foot of dump.](image)
2.3 In the month of April and May, following works were undertaken:

- De-silting of the settling ponds and excavation for new settling ponds, smoothening of terrace slopes, compaction of terrace surfaces with heavy duty bulldozers (Fig 20 & 21).
- Excavation of garland drains and drainages on terraces, stone pitching, placement of ERW pipes (Fig 17, 18 & 19) and laying of Geo-textiles and jute-mats or silpaulin (Fig 22 & 23).

2.4 After the onset of Monsoon in June, the dumps were inspected for choking of the drains to ensure proper water channelization and from the month of July onwards plantation of saplings was undertaken. Local community members having capacity to execute the required work were identified and contracts awarded to them as far as possible. Grass seeds were broadcast on Geo-textile and jute-mats to prevent surface erosion and fast growing Glyricidia spp was planted as pegs which helped in stabilizing the slopes. Subsequently, plantation of leguminous species such as of Acacia auriculoformis and Acacia mangium was taken up with 2mx2m spacing. These species do not require
aftercare, grow faster, and increase soil fertility by nitrogen fixation. In some area cashew trees were also planted in response to local demand.

**Initial Growth:** Initial growth of fast growing leguminous trees is shown in Figure 24.

![Initial Growth](image)

**Fig 24:** Figure showing initiation of vegetative cover on Pissurlem dump.

2.5 Acacia plantation took about 5 to 7 years to mature and in most places it has developed thick canopy almost resembling the natural vegetation of the region. In this time the dump has also stabilized and the greenery has begun attracting birds and other animals such hares and porcupines, even an occasional panther.

2.6 **Enabling activities:** The mining company has put in place company policies related to environment, biodiversity and water management and has developed Standard Operating Procedures for activities related to these company policies. They have also actively sought, and obtained, the help of institutions like Indian Council of Agricultural Research and the National Environmental Engineering Research Institute in the reclamation work.

3. **MONITORING:**

3.1. In order to access the effectiveness of mine reclamation works, it is important to regularly assess the environmental status during the reclamation process. As per the Mines and Minerals (Development and Regulation) Act, 1957, and
Goa Mineral Policy of 2013, the Directorate of Mines and Geology is responsible for monitoring of the stability of the dump slopes while the Department of Environment, acting through the State Pollution Control Board, is responsible for monitoring of various environmental parameters especially water quality, its discharge, effectiveness of settling ponds and drainages, and plantations etc. During the reclamation process the mining company used to prepare monthly environment management reports for submission to regulatory agencies including the MoEFCC, Indian Bureau of Mines, Goa State Pollution Control Board in prescribed formats. Verification of the reported parameters was carried out by these regulatory authorities from time to time.

4. OUTCOMES:

4.1. Mine reclamation is one of the key ingredients of Sustainable Development. Reclamation process in the study area went beyond re-establishment of greenery and included other aspects like discharge water quality, dump slopes stabilisation for preventing gully formation, effectiveness of settling ponds and drainages, water bodies, besides appropriate use of abandoned mining infrastructure like buildings etc. Application of well-planned scientific techniques resulted in win-win situation for the mining company as well as to the stakeholder communities.

4.2. Socio-economic benefits to the local community: Proper landscape restoration helped in alleviating the deleterious impacts of mining, rebuilding green cover, reducing air, water and soil pollutions, increase in biodiversity conservation, improving health of the people thus contributing to societal wellbeing.

4.3. Enhanced economic and other benefits for local communities: Both the company employees and the local communities involved in the works benefitted from the reclamation activity. Improvement in local livelihood was in terms of employment generated, contracts for carrying out works like afforestation, laying of geotextiles, de-silting of settling ponds, construction of settling ponds, rock walls and other civil works, including the dumping of material through local truck owners. Local communities also benefitted from renting out accommodation to the migrant reclamation workers. The afforested areas would be available as source of firewood by the locals in near future. There are no specific socio-cultural or religious benefits to the community. Other benefits
like, introduction of new value chains for Non-timber Forest Produce and other marketable products for benefit sharing are yet to begin.

4.4. **National and global benefits:** Increase in tree cover contributes towards meeting national goal of forest and tree cover and as also in achieving the committed targets under Nationally Determined Contributions as per Paris Accord and in restoring 13 million ha of degraded forest by 2020 under Bonn Challenge. Due to improvement in food, water and shelter the biodiversity in the area has also benefited.

4.5. **Ecological benefits:** Land reclamation significantly improves the ecological and environmental conditions of mined areas. The combined eco-environmental benefits of artificial woodland, reclaimed cropland, improved soil binding, reduction in siltation, nutrient cycling, water and air purification, and soil erosion or floods, biodiversity enhancement and conservation, maintenance of wildlife habitat have brought significant ecological benefits to the locality.

5. **FINANCING**

5.1. Financing mine reclamation was a part of the overall expenditure on mining as provided in the annual budget of the mining company. Total cost of Pissurlem dump reclamation including different activities like preparation of garland drains, de-siltation of existing drains, new settling ponds, rock walls, pipes, road roller, geotextile, jute mats, silpaulin and plantation was approximately INR 240 million. Although the amount invested in Training, capacity building and follow up could not be collected, it was ascertained through survey that the company hired technically qualified and experienced employees for the reclamation works.

6. **COMMUNICATIONS:**

6.1. This reclamation work has been studied by a premier Indian Institute, the National Institute of Rock Mechanics, Bengaluru, and has also earned appreciation by overseas agencies such as Golder Associates for design optimisation.

7. **LESSONS LEARNT:**

7.1. Mining has been a very important sector in the economic development of Goa being a significant foreign exchange earner. Responsible mining, when combined with effective and timely reclamation, can provide plentiful economic opportunities to the local communities without harming the ecology
and the environment. At present the mining sector in Goa is going through a critical phase on account of largescale environmental damages inflicted by irresponsible conduct of mining companies in the past. Good quality restoration works, such as the one carried out in the study area, can act as a model for suitable policy formulation for mining area reclamation. Reclamation of mined areas is a regulatory requirement and effective technologies have already been developed for this purpose. The only requirement is close monitoring of the conditions under which mining is permitted and enforcing the regulations without fail.

8. RESULTS AND DISCUSSIONS:
8.1.1. Timely and high quality restoration of mining site and overburden dump can minimize ecological and environmental costs of open cast mining and can provide multiple benefits such as enhanced water storage capacity, improved food security, increased biodiversity, creation of jobs, fast paced carbon sequestration, and increased resilience of the local communities to the changing climate.
Fig 25: Figure shows present growth of Cashew trees (6.61m at 7 years).

Fig 26: Figure shows present growth of *Acacia auriculiformis* & *Acacia mangium* trees (11.21m at 7 years).
Fig 27: Figure shows burning and cutting of *Acacia auriculiformis* & *Acacia mangium* trees from reclaimed dump site.

8.1.2. Following are the lessons learnt from the study conducted on reclamation of mined areas and dumping site in the Cumarconda forest landscape:

- Proper designing of benches and terraces of dump area by professional geologists is the foundation of mine reclamation works.
- Covering of dump slopes with geo-textiles or jute-mats or silpaulin prevents soil run off and gully formation and leads to quick stabilization of these slopes.
- Proper drainage of rainwater to settling ponds using ERW pipes prevents runoff and soil erosion.
- Local variety of grass with fast growing leguminous crops improves both soil fertility and physical structure of the soil as quickly as possible.
- Planting drought-resistant, fast-growing crop varieties accelerates reclamation process.
- Once the soil fertility has been improved by the leguminous fast-growing species, it should be replaced with preferred native species.
- Existing mining infrastructure of building and roads can sometimes be usefully converted to public utilities without compromising excessively on ecology.
- Public dissemination of information on successful reclamation efforts can help in reducing excessive opposition to mining on environmental grounds.

9. CONCLUSION

Relatively quick restoration of mining and dumping sites is possible through the application of well-designed methodologies that can be developed for each site by trained professionals. Proper designing of
benches and terraces of dump area by professional geologists is perhaps the most important part of the planning process. Surface soil erosion by water runoff and by winds may require innovative measures like use of geotextiles or jute mats. Existing pits can be used for storing water that would be crucial for plant survival during periods of water stress. Fast growing grasses, shrubs and trees, both indigenous and exotic, can bring the mining and dump sites under vegetative cover within a short time keeping soil particles intact thereby preventing erosion and stabilizing the site. Wherever necessary the non-local species can be easily replaced by native species once the soils have been stabilized.

The central problem in rehabilitation of mined land is not technical difficulties but the low priority often accorded to the task by the mining companies responsible for it. Since direct interventions by higher courts to enforce the conditions of mining regarding rehabilitation would not be possible in most places it is important to create duly empowered mechanisms with adequate public participation in all places where such rehabilitation is required to monitor progress and take preventive, corrective and punitive measures when necessary.

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• Filled in 13 number of questionnaires by various stakeholders (Mining company employees, Local people, local school teacher, Ex. Member of local body, Hotel owner, Truck driver and NGO member) of the study.

11. Photo Credits:-
• Google Earth
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• Staff of Goa Forest Department.

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