International Mining for Development Centre

MINE SITE REHABILITATION IN SIERRA LEONE – A RAPID APPRAISAL OF SELECTED SITES

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Summary

This report details the findings of a rapid field assessment of 5 industrial and 3 artisanal mining sites in Sierra Leone undertaken between Wednesday 21st and 25th of March, 2012. The field assessment was conducted to identify and prioritise issues in support of mine rehabilitation and mine closure planning. The field assessment team included the authors and representatives of the Environmental Protection Agency – Sierra Leone, the Ministry of Mineral Resources, and the Ministry of Land, Country Planning and the Environment.

The main findings of the assessment are:

- Mine rehabilitation and mine closure planning requires greater prioritisation at all of the mining sites visited.
- There was evidence of activities at each site to address mine rehabilitation and mine closure planning. Mine closure plans are required as a condition of mining. Some sites had prepared draft or operational mine closure plans.
- The active use of detailed closure plans was not witnessed. A number of sites with rehabilitation plans could not readily provide copies on request.
- Progressive rehabilitation of disturbed mining land following mining was not widely practiced. There is a large rehabilitation burden that requires prioritised attention at a minority of sites.
- Only a minority of sites have high-risk waste streams or process chemicals that require careful attention; the soil substrates at many sites are capable of supporting revegetation (with some significant exceptions); and the climate in Sierra Leone is broadly favourable for successful revegetation. Widespread burning practices by adjacent communities, however, do present some significant challenges during the re-establishment of vegetation.
- There is significant scope for a widening of the species used by mine sites for revegetation. A relatively narrow set of 'economic' species, dominated by cashew and oil palm, make up the majority of revegetation efforts at the sites visited.
- Nurseries were not common at the sites visited, with plants sourced from a variety of off-site locations including government nurseries. Where there are plans to establish site-based nurseries the EPA should establish timelines for the delivery of such commitments.
- A number of sites are staffed by very experienced long-term Sierra Leonean staff who are responsible for rehabilitation and have significant historical knowledge and practical skills. Other sites did not have Sierra Leonean environmental professionals – the relatively high turnover of expatriate staff poses a risk to the retention of knowledge about rehabilitation and other environmental issues at these sites.
- There is a need to undertake experimentation of species and substrates at the majority of sites – particularly during phases of the operation where active rehabilitation cannot yet be established for operational reasons.

- Progressive rehabilitation creates an opportunity for the demonstration of successful rehabilitation and signoff by the EPA. The EPA should develop success criteria in consultation with sites for rehabilitation outcomes, including productivity requirements for economic crops.
- Community involvement in the development of mine closure and rehabilitation plans or in active rehabilitation decision-making was not widespread.
- There is a need for the Sierra Leone government to prioritise the development of an environmental bonding system to provide financial surety to the government for rehabilitation in cases where companies do not fulfil their obligations.
- A number of programs have demonstrated that reclamation of artisanal diamond mining fields to productive agriculture is possible using limited financial resources and minimal technical assistance. The projects did not require modification of the soil substrates. These projects used local labour to fill in pits and contour land. The success of the programs, however, has been undermined by significant social and institutional challenges that did not ensure exhausted and reclaimed sites were not re-mined. It appears, however, that widespread reclamation of artisanal diamond mines is technically feasible at relatively low cost. Careful planning will be needed to address the social and institutional challenges to long-term reclamation success.
- There is an opportunity for government administrative fees collected from artisanal miners for the purposes of reclamation to be used to undertake demonstration projects. Such projects should involve the end users of the reclaimed land in the decision making and the practical tasks undertaken for the reclamation to generate ownership of the outcomes of the program.
- Alternatively, consideration should be given to the replacement of the fee with an environmental bond that is provided back to artisanal miners once post-mining pits have been refilled and re-contoured.

Table of Contents

Summary 2
Table of Contents 4
Acknowledgements 4
Glossary 5
Introduction 6
Methodology and site selection 7
Site Summaries 8
Project: Marampa 8
Project: Koidu Kimberlite Project 9
Project: Sierra Rutile 11
Project: Sierra Minerals (Gondama) 13
Project: Baomahun Gold 15
Artisanal Mining 16

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Glossary

AMD (Acid and Metalliferous Drainage) – contaminated liquid produced from the interaction of rock minerals with water. AMD is typically formed through the decomposition of sulphide minerals upon exposure to atmospheric conditions and contains dissolved metals and other minor elements that can be environmentally harmful. It should be noted that metal drainage may occur even in the absence of acidic conditions.

Capping – covering waste rock or tailings with an inert material to prevent water infiltration or to provide a plant growth medium

Closure Plan – a detailed report that includes all activities required before, during, and after the operating life of a mine to produce an acceptable post-mining landscape

Drill pads – areas that have been cleared for the purpose of allowing a drill rig to take sub-surface samples of mineral deposits

Environmental Bond - a financial agreement or arrangement between a mining company and a regulator to provide financial surety in the form of money or other acceptable forms of security against the potential environmental impacts and land disturbance that result from developing and mining the resources

Flocculent – a chemical additive that assists fine particulates to clump together to facilitate separation from a liquid

Hypogene – the primary ore minerals (typically sulphides) that were formed from hydrothermal solutions

Leachate – is any liquid that has extracted solutes, suspended solids or any other component of the material through which it has passed (can include potentially harmful substances). In the context of mining a leachate typical forms through the interaction of water, tailings and waste rock and may result in acid and metalliferous drainage.

Legacy – a degraded site or potentially hazardous material left from past mining activities that were not adequately rehabilitated

Reclamation – reclaiming land for a productive purpose (eg. food crops) including monoculture plantations

Recolonisation – re-establishment of plants that are self-sown or by vegetative regrowth

Rehabilitation – the process of improving disturbed land, including the development of new plant communities that may include some of the original plant species and may, or may not, have economic outcomes

Restoration – recreating an ecological community that existed prior to clearing, mining or other disturbance

Signoff – when government regulators and community formally accept the mining lease is no longer the mining company's responsibility

Slimes – finely-crushed by-product of ore extraction which remains in suspension in water

Substrate – used in this report to mean a plant growth medium

Tailings – materials leftover after separating the valuable fraction from the uneconomic fraction of an ore following mineral processing

Waste Rock – uneconomic rock extracted during mining that has not been processed.

Introduction

The rehabilitation of disturbed land is a key environmental and social issue in the mining sector. The legacy of disturbed sites has created long-term challenges in many jurisdictions. It is now common for governments to require financial guarantees and mine closure plans prior to mining as a means to manage both the risk and the exposure of governments to the potential environmental and social liabilities. This approach must also be combined with progressive rehabilitation of sites during the operational phases of mining while there are financial resources available to undertake works.

The Environmental Protection Agency - Sierra Leone is a key participant in recent reforms to strengthen mineral sector policy and is building its capabilities to regulate the environmental performance of the sector. There is therefore a need to prioritise the efforts on those issues and sites that potentially create the greatest risks.

This report details the findings of a rapid field assessment of industrial and artisanal mining sites in Sierra Leone to identify and prioritise issues in support of mine rehabilitation and mine closure planning. The report aims to assist the EPA to achieve effective rehabilitation outcomes, to ensure stable post mine landforms, and to reduce the risk of rehabilitation failure.

The field assessment team included the authors and representatives of the Environmental Protection Agency - Sierra Leone (Abdulai Kargbo), the Ministry of Mineral Resources (Eugene Norman), and the Ministry of Land, Country Planning and the Environment (Samuel Lapeia). Support for the assessment was provided by the International Mining for Development Centre (an initiative of the Australian Agency for International Development) and the United Nations Environment Programme.

Methodology and site selection

The assessment sought to answer the following question: what are the rehabilitation and closure risks associated with mining in Sierra Leone? A set of detailed assessment criteria were developed and applied to each site and form the basis of the site based reports to follow.

Five industrial mining sites and three artisanal site assessments were undertaken between Wednesday 21st and 25th of March, 2012. The field assessment team travelled by four-wheel drive. Companies were informed of the visit by letter with follow up telephone conversations. The field team were hosted by site based environmental staff and mine management who were available to answer questions and demonstrate rehabilitation activities.

Available documentation held by the EPA (mine closure plans and Environmental Impact Assessments) were reviewed for each site prior to the field assessment. A workshop was held with government staff, environmental consultants and professionals, and civil society representatives following the field appraisal to deliver preliminary results. An additional session was held with mining company staff. These fora provided valuable feedback to improve the results and to share the findings of the assessment. Circulation of the draft report will provide a further feedback mechanism and an opportunity for companies to provide clarification on points of difference.

This form of rapid appraisal was the most appropriate given the long distances required to be travelled to the sites, the limited time availability of international and local expertise, and the available financial and logistical resources. A rapid appraisal can assist to prioritise resources and focus on issues of greatest need.

Due to the nature of such an appraisal these results should not be seen as a definitive account of the environmental and social risk each site poses. No field based environmental tests were undertaken. The assessment is based on the professional judgement of the assessment team given the available time and resources and benchmarked against international practice. In particular the assessment of the acid and metalliferous drainage potential of each site was made based on the type of ore located at the site, the mining and operational methods employed, and the documentation available to the assessment team (e.g. the Environmental Impact Assessment). The authors recommend that detailed laboratory testing be undertaken to fully establish the risk of AMD and other hazardous materials (such as process chemicals) to inform decision-making about site performance.

Site Summaries

Project: Marampa

Operator: London Mining
Commodity: Iron-ore
Process: Tailings reprocessing
Phase: Operation (expansion planned)
Landscape location: High in landscape in the town of Lunsar

Summary: This operation has started rehabilitation of construction areas and has a small nursery with local and naturalised species. As they are mining legacy tailings material this provides the opportunity to rehabilitate legacy areas, which were abandoned by former owners. Tailings material does not appear to present a significant risk of AMD. The site has Sierra Leonean staff that can, in the future, assume key environmental roles.

Waste stream	
Types	Tailings
Process Chemicals	No
AMD risk of waste material	Low
Mining waste reuse	No
Rehabilitation	
Closure plan	Yes (and off-site offsetting; updated 2011)
Community involvement in plan	No
Evidence of rehabilitation	Minor (haul roads)
Evidence of progressive rehabilitation	No
Re-vegetation species	Cashews, oil palm, fruit trees, naturalized Gmelina, Albizzia (+ 5 species of cuttings with milky sap)
Community involvement in species selection	No (except off-site fruit trees)
Substrate growth potential	Yet to be demonstrated on new tailings but legacy tailings very high
Nursery	Yes – small (future plan to expand & establish in community; plants also sourced from Forestry Department)
Trial and experimentation	Minor – have identified colonizing species on legacy areas
Financial resources set aside	No, but closure costs calculated
Legacies	
Extent of disturbed land (current owner)	Low (re-mining of disturbed land)
Area rehabilitated (current owner)	None
Legacy (current owner)	Low
Legacy (past owners)	207 ha (but potential to eliminate with mining)

Recommendations:

- Assess the growth potential of plant species on final tailings material (as opposed to coarser legacy tailings).
- Engage the Community Steering Committee on the proposals set out in the closure plan and consider establishment of a sub-committee on issues of closure planning.
- Ensure community nursery is established and is able to grow a wide selection of species.

Figure 1. Marampa Mine. Top left: Community farming in legacy iron ore tailings. Bottom left: On-site nursery. Right: Revegetation using cuttings to provide shade along a walkway.

Project: Koidu Kimberlite Project

Operator: Koidu Holdings
Commodity: Diamond (Kimberlite)
Process: Crush and separation (open cut & planned shaft)
Phase: Operation (expansion planned)
Landscape location: High in landscape in the town of Kono

Summary: This site has demonstrated effective use of waste material in brick making for construction of resettlement housing and site needs. There are opportunities to begin rehabilitation of a closed slimes dam. In general the waste material does not appear to present a high risk of AMD.

Waste stream	
Types	Slimes, tailings, waste rock
Process Chemicals	No (flocculent in slimes)
AMD risk of waste material	Low
Mining waste reuse	Yes
Rehabilitation	
Closure plan	Not sighted (provisional plan submitted as part of EIA)
Community involvement in plan	No
Evidence of rehabilitation	No (old slimes dam un-rehabilitated)
Evidence of progressive rehabilitation	No
Re-vegetation species	Unknown
Community involvement in species selection	Unknown
Substrate growth potential	High (slimes moderate – may need capping)
Nursery	No (expressed plan to establish in community)
Trial and experimentation	No
Financial resources set aside	No
Legacies	
Extent of disturbed land (current owner)	Moderate (small lease site in active production)
Area rehabilitated (current owner)	None (waste dumps have very steep slope to lease boundary)
Legacy (current owner)	Low-Moderate
Legacy (past owners)	Low

Recommendations:

- A plant nursery should be established on site or within community (as per lease agreement)
- There is an opportunity to rehabilitate the disused slimes dam.
- The batter angle of the waste rock dump immediately adjacent to the lease boundary appears very steep and may be above agreed to requirements – there is a need to undertake detailed assessment as to whether this is the case and what options exist for remedy.
- Experimentation of the rehabilitation performance of waste rock material should be demonstrated.
- The number of environmental and social staff employed at the site is low for a site this size and there is an opportunity to employ some Sierra Leonean staff in these fields.
- Community involvement and input should be sought in revision of the closure plan.
- An opportunity exists for restoration of 'Monkey Hill' as an environmental demonstration project.
- There is an opportunity to consider waste rock and tailings backfilling as part of the waste management options for the expansion of the site. This option may present greater sustainability outcomes.

Figure Two. Koidu Kimberlite Project. Top left. Disused slimes dam. Top right: Waste rock dump steeply adjoining lease boundary – note the lease boundary rock wall at the foot of the dump. Bottom: Reuse of waste rock in wall construction (left) and brick construction (right).

Project: Sierra Rutile

Operator: Sierra Rutile
Commodity: Rutile & Illmenite
Process: Dredge & sort
Phase: Operations

Summary: This site has developed targets to catch up on a significant rehabilitation legacy. A management system and program of work is in place and appears to have resourcing and the commitment of the board of the company. The legacies, however, are significant and the targets that have been set are ambitious and will require dedicated attention. The site has retained a number of external consultants to assist in documenting and mapping the areas in need of rehabilitation and determining options. These efforts have followed previous EPA attention on this matter and are a demonstration of the positive role the EPA can play in improving performance. The site has long-term staff experienced in rehabilitation. Previous efforts, however, illustrate the challenges of rehabilitation on poor substrates. In particular, cashew rehabilitation undertaken in the early 1990s illustrated that productivity and growth rates were very low. These long-term results indicate that the mining method should be reassessed (to preserve topsoil) and other species should be used on the resulting sand tailings substrate.

Waste stream	
Types	Dredge sand & slime (no overburden or top soil)
Process Chemicals	Minor (xanthate and caustic soda used in sulphide flotation)
AMD risk of waste material	Low
Mining waste reuse	No
Rehabilitation	
Closure plan	Under revision (Not sighted)
Community involvement in plan	Unknown
Evidence of rehabilitation	Yes (both prior to and since conflict)
Evidence of progressive rehabilitation	Not sighted
Re-vegetation species	Cashew, oil palm, acacia, neem
Community involvement in species selection	Yes
Substrate growth potential	Low
Nursery	Yes (onsite & based in community but not sighted)
Trial and experimentation	Yes (Darwin, other consultants and University of Sierra Leone)
Financial resources set aside	Program of works
Legacies	
Extent of disturbed land (current owner)	2442 ha pond; 1010 ha tails; 1150 ha burrow pits
Area rehabilitated (current owner)	286 ha (~20 ha previously; 122 ha planned 2012 and set deadline for 2018 to catch up arrears)
Legacy (current owner)	1874 ha (have set targets and have plan of action)

Recommendations:

- The EPA in consultation with the site should set productivity targets for economic species to provide an agreed to minimum requirement prior to rehabilitation signoff. Adequate growth rates need to be demonstrated by the company as some rehabilitation sites visited during the assessment demonstrated relatively low productivity and an absence of self-generation of species even decades after establishment.
- The EPA should request a review of mining practice at the site and a benchmarking against international best practice in rutile mining. The extensive disturbance created by the pond dredge method should be justified against less intrusive mining methods. This review might also consider the efficacy of separate processing of mineralised topsoil to retain some topsoil for use in rehabilitation.
- The EPA should develop a process for signoff of rehabilitated land. The EPA and the site should look to progressively handover areas that are rehabilitated successfully. Such a process will also assist the community to adjust progressively to closure and the implications for changes in surface rent.
- Options should be explored to prevent regular fires in selected rehabilitation areas to demonstrate potential for re-colonisation of Acacia's and other species.

Figure Three. Sierra Rutile. Top left: Aquaculture ponds. Top right: Gully erosion on cashew rehabilitated sites. Bottom left: Acacia rehabilitation. Bottom right: Large ponds formed from rutile mining.




Project: Sierra Minerals (Gondama)

Operator: Vimetco
Commodity: Bauxite
Process: Washing (export ore)
Phase: Operations

Summary: The Gondama site has been mining bauxite for a number of years. The current owners have retained some experienced Sierra Leonean staff who are responsible for rehabilitation activities. This site was the only site to demonstrate progressive rehabilitation immediately following the extraction of ore. The current owners (who have only recently taken on operational control) do, however, have outstanding rehabilitation to catch up on and there is a substantial legacy of un-rehabilitated disturbed land from former owners. Three extensive tailings deposits are no longer in use. Natural re-colonisation of vegetation on these deposits is not widespread although it appears that some species have re-established. There is a medium term prospect that this tailings material could be re-mined again in the future and if well managed this may provide and opportunity to rehabilitate these areas.

Waste stream	
Types	Wash tailings (clay fines >2mm)
Process Chemicals	No
AMD risk of waste material	No (but slightly acidic leachate ~5.6 pH)
Mining waste reuse	No
Rehabilitation	
Closure plan	Draft
Community involvement in plan	Unknown
Evidence of rehabilitation	Yes (both prior to and since conflict)
Evidence of progressive rehabilitation	Yes
Re-vegetation species	Cashew, oil palm (plan details wider varieties)
Community involvement in species selection	Yes
Substrate growth potential	Moderate
Nursery	No (establishing one in April 2012)
Trial and experimentation	No
Financial resources set aside	Yes – provision in budget ($635k since 2008)
Legacies	
Extent of disturbed land (current owner)	218 ha
Area rehabilitated (current owner)	127 ha
Legacy (current owner)	91 ha
Pre-conflict disturbed	164 ha
Pre-conflict rehabilitated	52 ha
Legacy (previous owners)	112 ha

Recommendations:

- The EPA in consultation with the site should set productivity targets for economic species to provide an agreed to minimum requirement prior to rehabilitation signoff.
- The EPA should develop a process for signoff of rehabilitated land. The EPA and the site should look to progressively handover areas that are rehabilitated successfully. Such a process will also assist the community to adjust progressively to closure and the implications for changes in surface rent.
- Given the decision to use economic species in rehabilitation there is a need to train local community members in oil palm and cashew silviculture and maintenance.
- Trial selective handling of topsoil (i.e. removing the top 10cm of the soil profile from the remaining 40 cm and stockpile separately.
- The site should review species selection. Revegetation is currently restricted to economic species. There may be wider landscape benefits from using local native species for some planting.
- An assessment of the species recolonising the legacy tailings deposits should be undertaken prior to re-mining with a view to experimenting with such species in the future rehabilitation.
- Community involvement and input should be sort on the draft closure plan.

Figure Four. Left: Newly planted oil palm on recently mined land demonstrating progressive rehabilitation. Right: Three year old cashew rehabilitation showing solid growth rates.

Project: Baomahun Gold

Operator: Cluff Gold
Commodity: Gold (primary hypogene ore)
Process: Cyanide leach (open cut)
Phase: Feasibility
Landscape location: Headwaters of Teye River

Summary: This site is currently in a feasibility stage with key project components (e.g site access roads) under construction. The assessment therefore focussed on the planning that had been undertaken, the risks posed by the prosed mining methods, ore type, and waste streams, and the rehabilitation of disturbed land as a result of exploration. Due to the nature of processing primary sulphide rich ores using cyanide there is the potential to generate hazardous waste streams. AMD generation was considered to be likely and care should thus be taken in the design and implementation of relevant management systems and operational procedures to minimise risks. The upstream position of the site in the headwaters of the Teye River emphasises the importance of proper management of these risks.

Figure Five. Baomahun Gold Project. Left: Artisanal gold miners on an un-rehabilitated disused drill pad. Right: View east from the site towards proposed tailings dam location.

Waste stream	
Types	Tailings; waste rock
Process Chemicals	Yes (cyanide)
AMD risk of waste material	High
Mining waste reuse	No
Rehabilitation	
Closure plan	Unknown
Community involvement in plan	Unknown
Evidence of rehabilitation	No (drill pads un-rehabilitated)
Evidence of progressive rehabilitation	No
Re-vegetation species	Unknown
Community involvement in species selection	Unknown
Substrate growth potential	Tails & waste rock low (may require capping)
Nursery	No
Trial and experimentation	Not Applicable (NA)
Financial resources set aside	NA
Legacies	
Extent of disturbed land (current owner)	Low (drill pads)
Area rehabilitated (current owner)	None
Legacy (current owner)	NA

Recommendations:

- Rehabilitation of disturbed land from exploration drilling (drill pads) could be attempted in areas where further disturbance is unlikely as a means to demonstrate and improve knowledge in rehabilitation techniques. A range of locally collected species (planted just prior to the wet season) could be tested and monitored to determine which species persist.
- Future drill pads could be ripped and seeded immediately after drill core extraction, as is practice at many exploration sites.
- The site could begin establishment of a (community) nursery and grow a wide selection of native species.

Artisanal Mining

The field assessment team visited artisanal mining sites in Kono (alluvial diamond), Tongo Fields (alluvial diamond) and Baomahun (gold - alluvial and primary ore). Alluvial diamond mining has created large areas of land disturbance and very few sites have attempted rehabilitation. Process chemicals are not used in alluvial diamond mining. At the alluvial gold mining sites visited near Baomahun informants indicated that Mercury was not in widespread use. Informants did indicate that mercury is used during artisanal gold mining of primary ore, however the extent of this type of mining is very limited.

A number of programs have demonstrated that reclamation of artisanal diamond mining sites to productive agriculture is possible using limited financial resources and minimal technical assistance. A project undertaken by the Foundation for Environmental Security and Sustainability (FESS) with funding provided by Tiffany & Co. Foundation and the United States Agency for International Development reclaimed a number of sites using a community-led approach. At Congo Bridge in Kono ~45 acres of land was reclaimed to productive agriculture. The 6-month project employed around 300 people. The main activity consisted of filling in mining pits by shovel. Participants were paid a

wage and provided a daily meal. Post-reclamation agriculture has yielded good results. FESS provided tools and other resources, such as an agricultural expert to provide support and advice.

The rehabilitation did not require major modification of the soil substrates. The substrates did not appear to exhibit AMD or other difficulties. The success of the program has, however, been undermined by significant social and institutional challenges that did not ensure reclaimed sites were not re-mined.

FESS has been involved in other reclamation sites, such as near Bumpeh (not visited). Oil palm has apparently been planted at Bumpeh along with other agricultural crops. Challenges have been experienced in the maintenance of the oil palm due to regular burning. FESS has documented these projects in a series of reports[1].

The field team also viewed the site of a past MMR reclamation project at Kaisambo, Kono that is now in disuse. The team were told of community based rehabilitation projects in Kainsay and Bandafayi.

It appears that widespread reclamation of artisanal diamond sites to agriculture does not present significant technical difficulties with soil substrates or growth rates and can be done so at relatively low cost. The social and institutional challenges to ensure long-term rehabilitation success are, however, significant. Elaboration of these issues while important is beyond the scope of this assessment.

Administrative fees are collected by the government from artisanal miners for the purposes of rehabilitation. As noted by many others this creates a disincentive for miners to reclaim areas after mining and a responsibility on government departments to undertake programs. There is an opportunity for the fees collected by government to be used to undertake demonstration projects. Such projects should involve the end users of the reclaimed land in the decision-making and practical activities to generate ownership of the outcomes of the program.

Alternatively, consideration should be given to the replacement of the fee with an environmental bond that is provided back to artisanal miners once post-mining pits have been refilled and re-contoured.

[1] Foundation for Environmental Security and Sustainability (2007). Reclaiming the land after mining: Improving Environmental Management and Mitigating Land-use Conflicts in Alluvial Diamond Fields in Sierra Leone. http://www.fess-global.org/Publications/Other/Reclaiming_the_Land_After_Mining.pdf

Figure Six. Artisanal mining in Sierra Leone. Top left: Artisanal diamond miners re-mine previously reclaimed land in Kono. Top right: Land reclaimed by FESS to agricultural production in Kono. Middle: Alluvial gold mining, Baomahun. Bottom right: Artisanal gold mining of primary ore, Baomahun. Bottom right: Disturbed land from artisanal diamond mining, Tongo Fields.